# Rosebud County

# HIGH HAZARD LOCATION STUDY




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Board of County Commissioners
Rosebud County
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Transmitted herewith is the final report for the Rosebud County High Hazard Location Study. This report documents the results of the traffic studies and surveys performed in the evaluation of four locations in Rosebud County.

Included in this report are: 1) a thorough assessment of the existing conditions at each site; 2) an accident analysis of all reported accidents at each site during the four-year period from January, 1978 through December, 1981; 3) a short-term, low-cost improvement program complete with a prioritized project list based on the relative hazardousness of each site; and 4) a series of long-term, more expensive solutions, generally involving road reconstruction.

It has been a pleasure working with you, and we appreciate your guidance throughout the project. We hope you are satisfied with this report and find it useful in reducing traffic hazards in Rosebud County. If you have any questions or are in need of additional information, please don't hesitate to contact us.

Respectfully submitted,

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# ROSEBUD COUNTY HIGH HAZARD LOCATION STUDY

Prepared For:

Rosebud County, Montana

In Cooperation With:

State of Montana Department of Justice

Highway Traffic Safety Division

and

the Montana Association of Counties

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Helena, Montana

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## TABLE OF CONTENTS


| | | |
|---|---|---|
| I. | Introduction . . . . . . . . . . . . . . . . . . . . . . . . | 1 |
| II. | Summary and Recommendations . . . . . . . . . . . . . . . . | 2 |
| III. | Procedure and Methodology . . . . . . . . . . . . . . . . . | 8 |
| IV. | Site Analysis . . . . . . . . . . . . . . . . . . . . . . . .<br>Sites 1 through 4 | 14 |
| V. | Bibliography | |
| VI. | Appendix A<br>Indicator Values for Hazard Index<br>Benefit/Cost Analysis Format | |

## LIST OF TABLES


| | | |
|---|---|---|
| Table 1 | List of Sites . . . . . . . . . . . . . . . . . . . . . . | 1 |
| Table 2 | Short- and Long-Term Improvement Costs . . . . . . . . | 3 |
| Table 3 | Hazard Index Ranking. . . . . . . . . . . . . . . . . . . | 5 |
| Table 4 | Benefit/Cost Ranking . . . . . . . . . . . . . . . . . . . | 6 |
| Table 5 | Priority Ranking of Short-Term Improvements . . . . . | 7 |


## LIST OF FIGURES


Figure I-1 Site Location Map

For each site the following figures are shown:

Figure A Site Location Map
Figure B Existing Conditions
Figure C Composite Collision Diagram
Figure D Recommended Improvements


## PHOTOGRAPHS

Photo plates are included for each site in their appropriate sections.

# CHAPTER I
# INTRODUCTION

# CHAPTER I

# INTRODUCTION

The purpose of this report is to evaluate four hazardous road locations in Rosebud County and to recommend appropriate improvements. The sites were chosen by Rosebud County with the assistance of the Department of Justice, Highway Traffic Safety Division, based on accident history and roadway characteristics. The sites are referenced in Table 1 below and shown on a location map, Figure I-1.

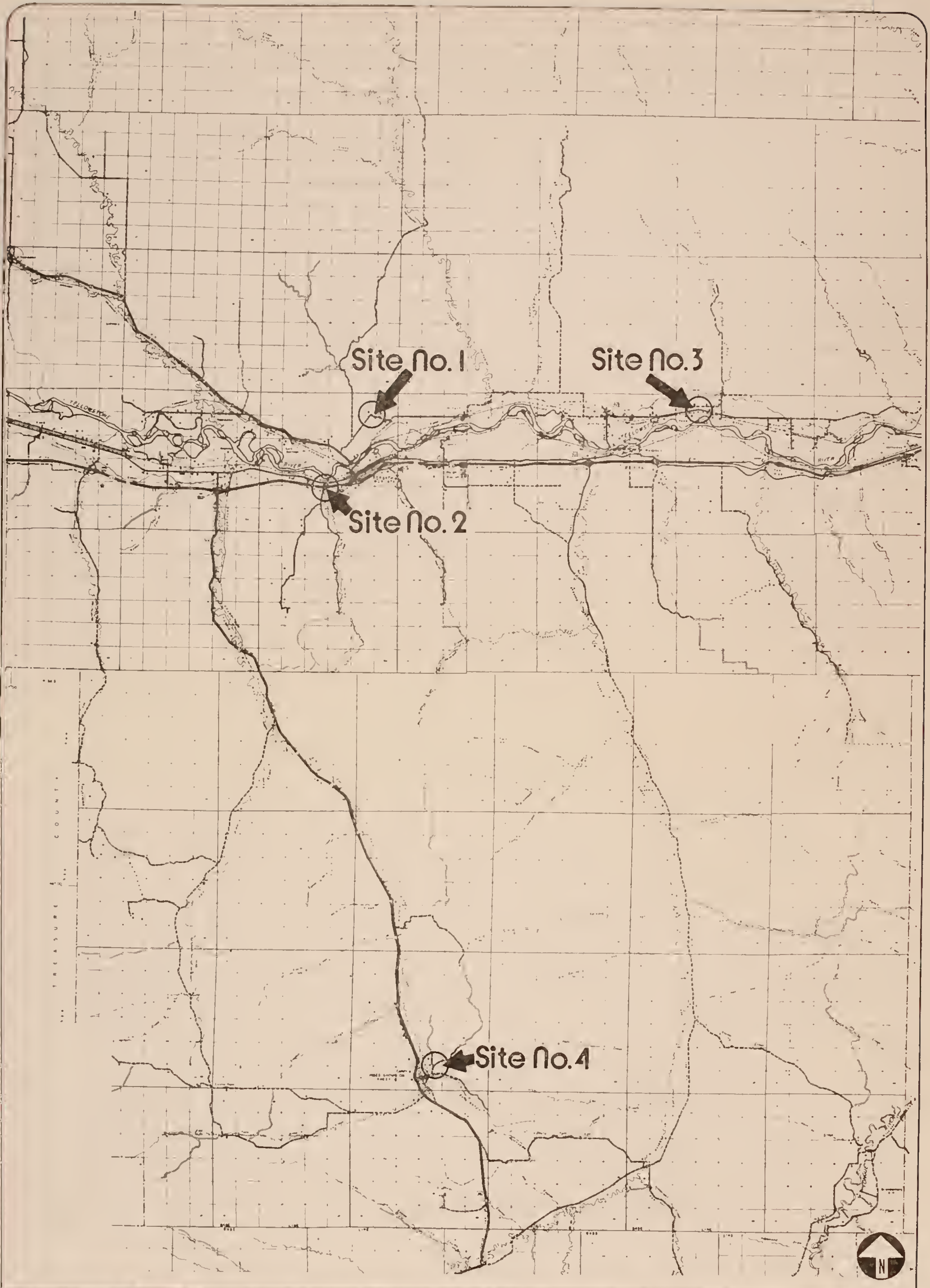
The analysis contained within this report is based on procedures outlined in Report No. FHWA-RD-77-83, Identification of Hazardous Locations, as refined by DCA Project No. 79-04-01-01, Preliminary Evaluation Program for High Hazard Location Study, Yellowstone County, Montana.

Short-term and in some cases long-term improvements that would reduce or eliminate hazardous conditions have been included for each site. Emphasis was given to relatively low-cost improvements in an effort to present solutions within the funding capabilities of the County. A priority ranking of site improvement projects was developed based on a composite hazard ranking and benefit/cost ratios.

## TABLE NO. 1

## LIST OF SITES

| | |
|---|---|
| Site #1: | Cartersville Road - north of Forsyth |
| Site #2: | Smith Creek Road at Golf Course and I-94 Overpass - west of Forsyth |
| Site #3: | Cartersville Road at Sand Creek Bridge - northeast of Forsyth |
| Site #4: | Intersection of Power Road and Pine Butte Drive - Colstrip |




# Rosebud County High Hazard Site Locations

Figure No. I·I Rosebud

# CHAPTER II

# SUMMARY & RECOMMENDATIONS

# CHAPTER II

## SUMMARY AND RECOMMENDATIONS

### A. Summary

The purpose of this study is to identify the factors contributing to unsafe traffic conditions at four hazardous locations selected by Rosebud County, and to recommend improvements that would remedy the unsafe conditions. At each location, a field inspection was made, the site geometrics were recorded, site condition sketches were made, and manual and machine traffic counts were taken. In addition, the accident records for the last four years were obtained from the Department of Justice and analyzed.

Solutions to the problems that were identified included short-term low-cost traffic management-type improvements, and long-term more permanent solutions generally involving road reconstruction and higher costs. These recommended improvement costs are summarized in Table 2.

The four hazardous sites selected by Rosebud County had 14 accidents reported during the four-year period from 1978 through 1981. These accidents included 1 fatality, 10 injury and 3 property damage accidents.The annual cost of these accidents, according to National Safety Council figures, is $56,153. Based on the average accident reduction figures established by the Department of Highways, the short-term improvements recommended in this report could eliminate 50 percent of these accidents.

### B. Short-Term Improvements

The short-term improvements recommended for each site concentrate on supplying better guidance to the motorist through conventional signing and striping methods and on improving sight distance within existing right-of-way limits. In general, the short-term improvements for each site cost less than $2,300. The total cost of all short-term improvements is $7,091, based on current construction costs.

### C. Long-Term Improvements

Long-term improvements were recommended where deficiencies at a site could not be completely corrected by short-term, low-cost improvements. The long-term improvements generally consist of minor road reconstruction. Due to the nature and the time frame involved with these long-term improvements, it is recommended that they be implemented as funds become available. The total cost of all the long-term improvements is $9,500, based on 1982 construction costs.

TABLE NO. 2

SHORT- & LONG-TERM IMPROVEMENT COSTS

| Site No. | Site Name | Short-Term Improvement Cost | Long-Term Improvement Cost |
|---|---|---|---|
| 1. | Cartersville Road | $ 723 | $4,500 |
| 2. | Smith Creek Road | 2,043 | 5,000 |
| 3. | Cartersville Road at Sand Creek | 2,300 | * |
| 4. | Power Road and Pine Butte Drive | 2,025 | * |
| Total Cost: | | $7,091 | $9,500 |

* At Sites 3 and 4, the short-term improvements adequately addressed the problems; therefore, no long-term improvements have been recommended.

D. Prioritization

To aid the County in deciding the order of implementation for the short-term improvements, a Priority Ranking has been provided. This ranking evaluates the relative hazardousness of each site and the cost of the short-term improvements.

To evaluate the relative hazardousness of each site, a Hazard Index was calculated. This Hazard Index is based on three accident indicators (number of accidents, accident severity, and accident rate) and four "non-accident" indicators (volume/capacity ratio, sight distance ratio, driver expectancy, and information system deficiency). Each site has been ranked according to the accident and non-accident indicators, and the Hazard Index is shown in Table 3.

To determine the proper order of implementation for the short-term improvements, the cost of the improvement must be evaluated with respect to the average traffic volume and the site's Hazard Index. Cost factors and benefit/cost ratios were calculated for each site improvement, and are shown in Table 4.

A Priority Index, which is a weighted average of the Hazard Index and the Cost Factor, was computed for each site. The Priority Index ranking is the recommended order of implementation and should be used as the major consideration in selecting the order of funding for these sites. Due to possible funding limitations, it may be advantageous to skip one or two improvement projects in order to implement a greater number of improvements. The Priority Index ranking of the short-term improvements is shown in Table 5.

No prioritization has been offered for the long-term improvements due to the costs involved. It is recommended that the long-term improvements be implemented as funds and/or right-of-way become available.

E. Implementation

The short-term improvements recommended in this report address the major problems at each site. After evaluating the availability of funds, Rosebud County should schedule the implementation of the short-term improvement projects according to the priority listing shown in Table 5. Due to the relatively low cost of these improvements, it is believed that implementation could be scheduled over a two- to three-year period without becoming a financial burden on the County. It is recommended to complete the short-term improvement program prior to funding any of the long-term improvements.

All long-term improvements are considered of equal importance and should be implemented as funds become available.

Throughout this report, when warning signs are recommended, the 30" x 30" size sign is to be used. Likewise, all advisory speed plates should be of the 18" x 18" size. The placement of all signs, delineators, guard rails, and pavement markings should always be in conformance with the Manual on Uniform Traffic Control Devices.

## TABLE NO. 3

HAZARD INDEX RANKING

| Ranking | Site No. | "Accident" Indicators | Ranking | Site No. | "Non-Accident" Indicators |
|---|---|---|---|---|---|
| 1 | 2 | 40.90 | 1 | 1 | 23.89 |
| 2 | 1 | 39.86 | 2 | 2 | 22.87 |
| 3 | 3 | 37.00 | 3 | 4 | 16.86 |
| 4 | 4 | 24.48 | 4 | 3 | 7.55 |

| Ranking | Site No. | Hazard Index |
|---|---|---|
| 1 | 2 | 63.77 |
| 2 | 1 | 63.75 |
| 3 | 3 | 44.55 |
| 4 | 4 | 41.34 |

TABLE NO. 4

BENEFIT/COST RANKING

| Ranking | Site No. | Short-Term Improvement Cost | Cost Factor Indicator | Benefit/Cost Ratio |
|---|---|---|---|---|
| 1 | 2 | $2,043 | 88 | 6.2 |
| 2 | 4 | 2,025 | 100 | 2.8 |
| 3 | 1 | 723 | 87 | 2.6 |
| 4 | 3 | 2,300 | 75 | 2.6 |

TABLE NO. 5

PRIORITY RANKING OF SHORT-TERM IMPROVEMENTS

| Priority Ranking | Site No. | Site Name | Short-Term Improvement Cost | Priority Index |
|---|---|---|---|---|
| 1 | 2 | Smith Creek Road | $2,043 | 69.83 |
| 2 | 1 | Cartersville Road | 723 | 69.56 |
| 3 | 4 | Power Road and Pine Butte Drive | 2,025 | 56.01 |
| 4 | 3 | Cartersville Road at Sand Creek | 2,300 | 52.16 |

# CHAPTER III

# PROCEDURE & METHODOLOGY

## CHAPTER III

## PROCEDURE AND METHODOLOGY

### A. Field Investigation and Data Collection:

The conclusions and recommendations contained in this report are the product of an extensive data gathering procedure undertaken for each high hazard location. It is impossible to obtain a realistic view of conditions at a particular site without firsthand experience at the site. The background data collected during initial research and on-site visits revealed the circumstances that make one particular location more hazardous than another. The data gathering procedure used during this study included (in chronological order): 1) initial accident research; 2) initial site visit and site identification; 3) site survey; 4) site photography; 5) detailed site sketch; 6) traffic counts; 7) on-site accident analysis; 8) ball bank testing; 9) sight distance determination; 10) subjective rating of site drivability and physical layout; and 11) observation of driver characteristics and quality of travel. The following section contains a brief explanation of each activity undertaken by two field technicians during the data collection stage of this project.

#### 1. Initial Accident Research

The Montana Department of Justice, Highway Traffic Safety Division initially identified accident clusters for individual counties from historical accident reports and accident location plot maps. The accidents within a particular area were then summarized in a list and submitted to Robert Peccia & Associates. All accidents listed were then retrieved and copied from microfilmed records of accident reports. The accident reports were grouped by general location and listed in chronological order. Accidents that occurred during the study period (January, 1978 to December, 1981) were used for further analysis. Those accidents that occurred before or after the study period were retained for reference.

#### 2. Initial Site Visit and Site Identification

The initial visit to each cluster area was made with a representative of each county, if possible, and a representative of the Montana Department of Justice. At this time, the specific high hazard location was identified through the analysis of each group of accident reports and through the input of the local representative. The firsthand knowledge of the long-term accident history and traffic characteristics at each site thus obtained was extremely beneficial.

#### 3. Site Survey

Field technicians utilized survey equipment to identify the physical layout of the roadway itself. Data gathered during the site survey included av-

erage road grades within the site, roadway alignment, superelevation in curves, roadway widths, and identification of right-of-way widths.

4. Site Photography

During site visits, many photographs were taken to illustrate site characteristics or to identify deficiencies within the site. These photographs were utilized in many ways during the preparation of the report and the report graphics. Aerial photography at the largest scale possible was obtained and used during base map preparation and site analysis. In most instances, the combination of aerial photography and extensive "on the ground" photography minimized the need for return visits to the sites.

5. Site Sketch

Sites were stationed at 100-foot intervals and the locations of significant features were mapped. This phase of the data collection involved extensive field measurements of site details including site locations, pavement marking changes, roadside delineators, utilities adjacent to the roadway, fencing, and roadside vegetation. Site photography was also extensively utilized to produce accurate sketches.

6. Traffic Counts

Available traffic count data was obtained from the Planning and Research Bureau of the Montana Department of Highways and used for as many sites as possible. For those sites lacking such information, 24-hour recording traffic counters set to record traffic volumes in 15-minute intervals were set at the required locations. If the site included a major intersection and traffic was significant, peak hour turning movements were conducted in addition to 24-hour traffic counts. This traffic data was used to determine the average daily traffic (ADT) and for capacity analysis. Traffic counts conducted by Robert Peccia & Associates were submitted to the Department of Highways to augment their traffic count data.

7. Accident Analysis

All reported accidents for each specific site location that occurred during the study period of 1/78 through 12/81 were plotted on collision diagrams. Accident data for the study period was also summarized and used in the field. These summaries allowed the field technicians to reconstruct the accidents and to better understand the circumstances that made for unsafe driving conditions at a particular site. The number of accidents and traffic volumes were used to compare accident rates of specific sites.

It should be noted that alcohol-related accidents have been categorized in two ways on the accident data summary sheet contained in each site analysis. In the first instance, alcohol was listed as a possible violation by the driver of the vehicle (i.e., driving while intoxicated.) In this item, alcohol was treated in the same manner as reckless driving, speeding, and other driving violations. In addition, an accident tally was completed that summarized the number of times drinking was listed as a possible violation and identified the number of accidents that had some form of alcohol involvement by the driver or passengers.

8. Ball Bank Testing

The vehicle utilized during field data collection was equipped with a ball bank indicator or safe curve speed indicator. The instrument provides a simple way to establish the safe advisable speed necessary to comfortably pass through a curve where no speed restrictions exist. The posted advisory speeds on curves were also verified through the use of this instrument. Only those sites with unrestricted traffic flows were tested.

9. Stopping Sight Distance Determination

Sight distance is a major element in the safe and efficient operation of any roadway. Stopping sight distance, the minimum distance needed for a vehicle travelling near or at the design speed for the roadway to stop for an object in its path, was measured by two field technicians. Actual sight distance limitations were measured using an eye height of 3.75 feet and an object height of 0.5 feet. Vehicle speed, roadway surface conditions, obstructions, and driver characteristics were also considered in sight distance measurement. The measurement of sight distance at intersections required the development of a minimum sight triangle, which considers unobstructed sight distance along both roads at an intersection and across the included corner.

10. Subjective Rating of Site Drivability and Physical Layout

After the field data was gathered for each site, two field technicians independently rated the drivability of the site and the completeness of the information system presented to motorists entering the site. The rating was completed on the Driver Expectancy and Information System Deficiencies forms, which are discussed in the following section of this chapter. These ratings present a relatively unbiased impression of the site layout and characteristics, since they were arrived at independently by technicians who were not familiar with the site prior to the data collection phase of the project.

11. Observation of Driver Characteristics and Quality of Travel

During the collection of field data, time was taken to observe motorists' driving habits through each site. Field observations of drivers were completed both during day and nighttime light conditions to obtain an overall impression of driver tendencies and to detect deficiencies in the overall layout of the site.

B. Analysis of Data and Calculation of Hazard Indices:

A hazard index was calculated for each site based on the following seven indicator values:

1. Number of Accidents
2. Accident Rate
3. Accident Severity
4. Volume/Capacity Ratio
5. Sight Distance
6. Driver Expectancy
7. Information System Deficiencies

For each indicator, a value between 0 and 100 was calculated, with 0 representing no hazard and 100 representing the most hazardous. The indicator values were then weighted and totalled according to accepted Department of Justice methods and values outlined in DCA Project No. 79-04-01-01 to yield the Hazard Index.

The improvement costs for each site were calculated using current construction costs and weighted against the accident reduction benefits associated with the type of improvement. In addition to the cost/benefit ratio, a cost factor was determined. The cost factor represents the improvement costs per vehicle computed by dividing the total cost for improvements at a site by the number of vehicles entering that location over a period of five years. A five-year period is used because that is the average service life of the recommended short-term improvements. The form used to compute the cost factor is shown in Figure A2 in the Appendix.

The final phase in the analysis was to determine the Priority Index (P.I.). The Priority Index is the weighted average of the Hazard Index (H.I.) and the Cost Factor (C.F.), as shown in the following equation:

$$P.I. = 0.75\ (H.I.) + 0.25\ (C.F.)$$

The site improvements were then ranked according to priority based on the Accident Hazard Indicators, Non-Accident Hazard Indicators, Cost/Benefit Ratios, Hazard Index, and Priority Index.

The following section contains a brief explanation of each of the Hazard Indicators and the Cost/Benefit Ratio.

1. Number of Accidents

Accident records for a three-year period from January, 1978 through December, 1981 were obtained from the Montana Highway Patrol. This accident data was then used to determine the three "accident" indicators (number of accidents, accident rate and accident severity). The annual average number of accidents occurring at each site was used to calculate this indicator value. Figure A3 in the Appendix shows the relationship between the annual number of accidents and the indicator value.

2. Accident Rate

This indicator is used to compensate for the wide range of traffic volumes found throughout the study sites. The average daily traffic entering each site was calculated and adjusted to represent a three-year volume. The total number of accidents per million vehicles entering the site was then calculated, resulting in the accident rate. This figure was entered into Figure A4 in the Appendix to yield the corresponding indicator value.

3. Accident Severity

This indicator evaluates the severity of the accidents occurring at each site in terms of dollars. A "Relative Severity Index" (Table A1 of the Appendix) was used to rate each accident according to accident type and to assign a corresponding accident cost. The R.S.I. values used are those in-

cluded in DCA Project No. 79-04-01-01. The average of the R.S.I. values at each site was calculated and entered into Figure A5 in the Appendix to determine the appropriate indicator value.

4. Volume-to-Capacity Ratio

The individual characteristics of the sites vary greatly. This indicator value normalizes each site with respect to lane width, geometrics, traffic mix and volume. The capacity of each site was calculated for Service Level C in accordance with the Highway Research Board, Special Report 87, Highway Capacity Manual. The volume used represents the average daily traffic entering the site. The equation used to compute the index is as follows:

$$\frac{V}{C} = \frac{ADT}{24\ (\text{Capacity})}$$

This ratio was entered into Figure A6 (found in the Appendix) to yield the corresponding indicator value.

5. Sight Distance

The sight distance at a particular site is an excellent indicator of the hazardousness of that location. Critical sight distances were measured at each location based on the criteria outlined in the DCA Project No. 79-04-01-01. The desirable sight distances for each particular location were then calculated according to the AASHO Manual Geometric Design of Rural Highways. For each case, the ratio of the existing versus the desirable Sight Distance was calculated. The two worst cases at each site were evaluated and a weighted average was computed by assigning a weight of two to the worst rating and one to the other rating. This weighted average sight distance ratio entered into Figure A7 (found in the Appendix) yields the corresponding indicator value.

6. Driver Expectancy

The driver expectancy indicator is a purely subjective method of evaluating the ability of the average motorist to negotiate a particular section of roadway or intersection. Each site approach was rated using the criteria included on the driver expectancy form shown on Figure A8 in the Appendix. Each site was evaluated individually by two technicians and the ratings were averaged. The two approaches with the worst ratings were used in the calculation of the indicator value. A weighted average of the two ratings was calculated according to DCA weighting methods and used in Figure A9 of the Appendix to compute the corresponding indicator value.

7. Information System Deficiencies

Similar to the driver expectancy ratings, this indicator is based on the subjective judgment of the evaluator. This rating consists of evaluating the signing and striping systems at each site with respect to the systems' ability to inform and guide the motorist through a particular section of road or in-

tersection. The actual criteria used in this evaluation are shown on the rating form (Figure A10) found in the Appendix.

All site approaches were independently rated by two technicians and their ratings averaged. Only the two worst average approach ratings were actually used to calculate this indicator. A weighted average of the two ratings was computed according to the weighting formula outlined in DCA Project 79-04-01-01. This weighted average was entered into Figure A11 in the Appendix to yield the appropriate indicator value.

8. Benefit/Cost Ratio

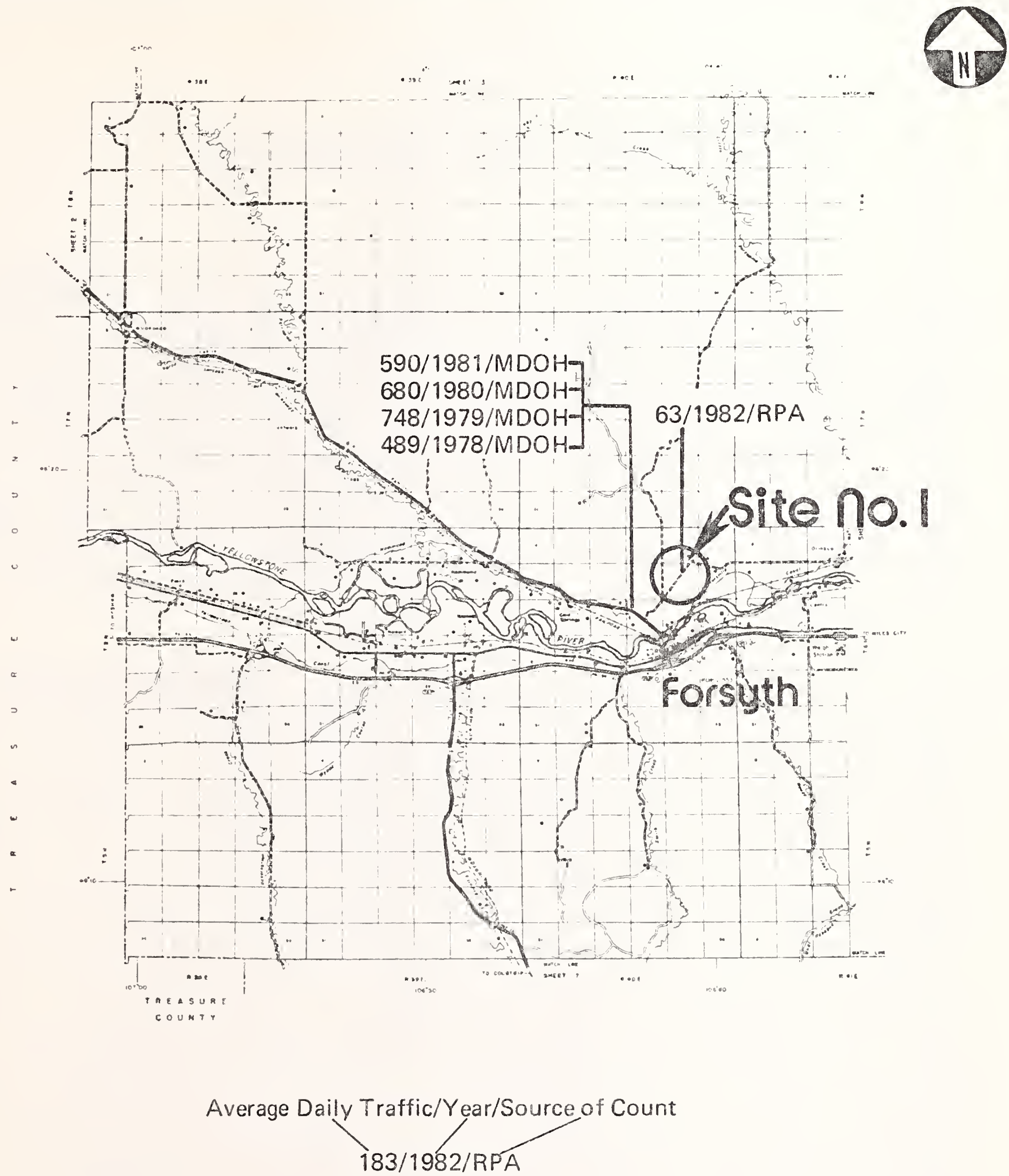
Each site was analyzed and improvements were recommended. The improvement costs were estimated based on current Department of Highways statewide average construction costs. Although it is likely that Rosebud County will implement some of the improvements with County forces, the "contracted" construction costs were used throughout for comparison purposes.

The benefits of each improvement were calculated based on the anticipated accident reduction resulting from that particular improvement. The Montana Department of Highways method for calculating the benefit/cost ratio was used and the computation format is shown in Figure A12 of the Appendix. A ranking of each site based on the benefit/cost ratio was compiled and is presented in Table 4. The site improvement yielding the greatest accident reduction benefit per dollar spent was given the highest ranking.

# CHAPTER IV

# SITE ANALYSIS

Site no. 1




# SITE LOCATION

# TRAFFIC COUNTS

## CARTERSVILLE ROAD·FORSYTH

Figure No.

**1·A**

Rosebud

# SITE #1

## Cartersville Road - North of Forsyth

### A. Location

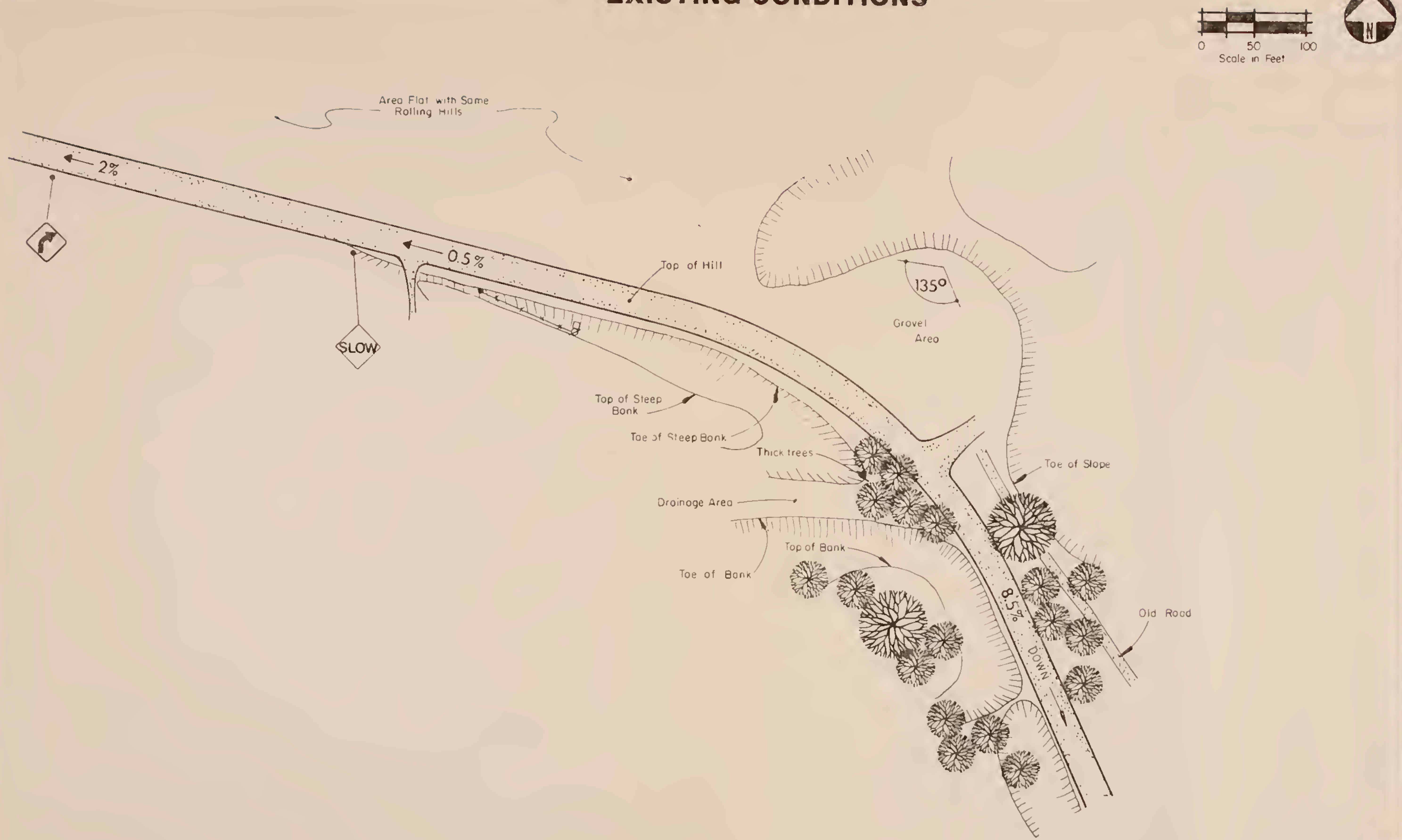
Site #1 is located on Cartersville Road approximately two miles directly north of Forsyth. The site consists of a relatively sharp curve and a steep grade extending from the top of a high plateau down to the low lands adjacent to the Yellowstone River. Long, straight sections of roadway approach the site from both the east and west. The site is located in a lightly developed rural area. Some scattered residential development exists near the site; however, most land in the area is used as pasture for livestock. The Cartersville Road serves as a major east-west route for residents living on the north side of the river and provides access to bridges over the Yellowstone River at Forsyth and Rosebud. The location of Site #1 is depicted in Figure 1A.

### B. Existing Conditions

The gravel-surfaced roadway at this site varies from 24 to 28 feet in width. Grades on the west approach to the curve range from 0.5 to 2.0 percent to the west. A long downgrade which begins in the curve and extends eastward attains a maximum grade of approximately 8.5 percent. This grade, coupled with the extreme "washboard" road surface and large gravel surface material in places, makes for difficult conditions for motorists on the hill. Based on field observations, it is evident that many vehicles, especially heavy farm trucks, have trouble negotiating the hill and have difficulty maintaining even minimal travel speeds. Sight distance on the curve-hill combination varies from 170 feet for eastbound drivers to 210 feet for westbound motorists. Signing at the site consists of a curve warning sign (W1-2R) located approximately 500 feet from the curve and a non-standard "Slow" sign located approximately 250 feet from the beginning of the steep grade. There are no posted speed limit signs near the site, so it is assumed that the speed limit is 55 mph throughout the site. Because of the nature of the soils and base materials in the area, steep terrain tends to erode quite easily. There are several locations on the downgrade where washouts up to three feet deep extend dangerously close to the lanes of travel. Site conditions are depicted in Figure 1B and in the photographs contained in Plate 1.

Based on machine counts of 24-hour traffic volumes conducted by Robert Peccia & Associates during October, 1982, the ADT for this section of Cartersville Road was determined to be 63 vehicles per day.

# EXISTING CONDITIONS




CARTERSVILLE ROAD·FORSYTH

Site No. 1

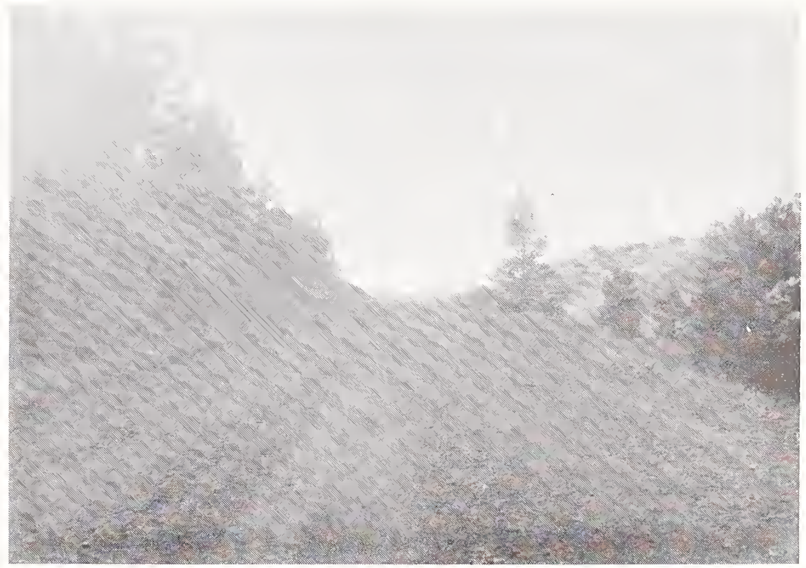
Figure No.
I·B
Rosebud

# Existing Site Conditions

View of west approach to curve on Cartersville Road.

West approach to curve at top of hill. Note sight distance limitation resulting from curvature and grade change.

View of east approach to curve. Note the "washboard" surface of the gravel roadway. The grade at this location within the site is 8.5 percent. Also note steep areas adjacent to the roadway.



View of east approach to the curve. Note sight distance limitations experienced at the top of the hill. This situation is compounded by blinding sun conditions during the late afternoon and early evening hours.

Plate 1

C. Accident History

A total of three accidents were reported at Site #1 during the four-year study period. Two of the three accidents resulted in injuries to a total of three persons. Both injury accidents were caused by excessive speed resulting in a loss of control by the driver. In both cases the vehicles left the roadway and overturned. The other accident reported during the study period resulted from a collision with a horse standing in the roadway. All three accidents occurred during nighttime driving conditions and only one accident occurred under adverse weather and icy road conditions. Alcohol was involved in two of the three accidents. The composite collision diagram for this site is depicted in Figure 1C. The accident rate at Site #1 is 32.6 accidents per million vehicles entering (MVE).

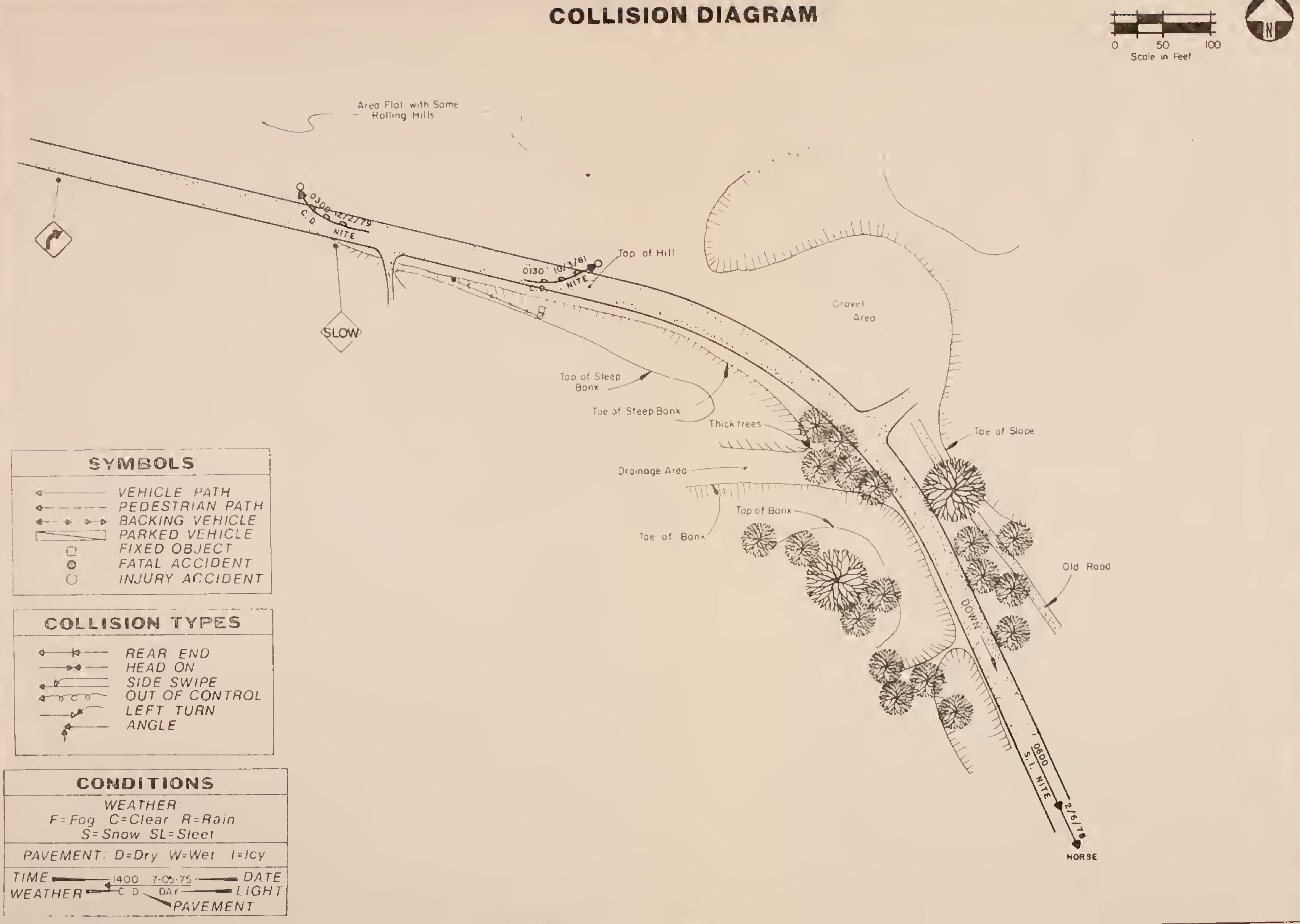
D. Recommendations

The driving conditions at this site are somewhat different than the surrounding sections of Cartersville Road. After driving on a relatively flat tangent approach from the west, the motorist is faced with an abrupt change in both horizontal and vertical alignment. The length and steepness of the hill at this site are uncommon for this area. Unlike the approach from the east, where the hill can be seen well in advance, the motorists approaching from the west is unaware of the hill due to the sharp drop-off. The curve unfortunately occurs at the same location as the change in grade. This steep grade is undesirable, but unavoidable without costly reconstruction. The long-term improvements recommended for this site deal with the sight distance limitations at this site, while the short-term improvements outlined below address the site signing and delineation.

1. A vehicle equipped with a ball bank indicator was used to identify the maximum safe speed for the curve at this site. It was determined that a speed of 25 mph is appropriate for this location. According to the Manual on Uniform Traffic Control Devices, the existing curve warning sign (W1-2) located on the west approach should be used only for curves with recommended speeds between 30 and 60 mph. The more appropriate turn warning sign (W1-1) which is used for curves with recommended speeds of 30 mph or less, should be used. It is recommended that the existing curve warning sign be removed and replaced with a turn warning sign accompanied by a 25 mph advisory speed plate (W13-1). A similar combination of signs should be installed on the east approach approximately 250 feet from the beginning of the curve.

2. The non-standard "Slow" sign located on the west approach does not convey the most appropriate warning. It is recommended that this sign be replaced with a hill warning sign (W7-1). The hill warning sign conveys a warning or caution to the motorist while also properly identifying the upcoming situation.

# COLLISION DIAGRAM




CARTERSVILLE ROAD·FORSYTH

Site No. 1

Figure No.
1·C
Rosebud

# ACCIDENT DATA

*Cartersville Road North of Forsyth*

SITE NUMBER 1 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

| 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|
| 1 | 1 | | 1 |

NUMBER OF ACCIDENTS BY DAY OF WEEK

| Sun. | Mon. | Tues. | Wed. | Thurs. | Fri. | Sat. |
|---|---|---|---|---|---|---|
| | 1 | | | | 1 | 1 |

NUMBER OF ACCIDENTS BY MONTH

| Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | | | 1 | | 1 |

NUMBER OF ACCIDENTS BY TIME OF DAY

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1 | | | 1 | | | | | | | | | | | | | | | | | | |

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

| Daylight | Dark | Dawn | Dusk |
|---|---|---|---|
| | 3 | | |

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

| Dry | Wet | Snow | Ice | Other |
|---|---|---|---|---|
| 2 | | | 1 | |

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

| Clear | Rain | Snow | Fog |
|---|---|---|---|
| 2 | | 1 | |

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

| Angle | Turn | Rear End | Fixed Obj. | Ped. | Animal | Side-swipe | Non-Col | Head-on | Backing |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | | 1 | | 1 | | |

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

| No Ap. Violation | Drinking | Reckless Driving | Speed | Right-of Way | Improper Passing | Improper Backing | Improper Turning | Other |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | | | | | |

NUMBER OF ACCIDENTS BY SEVERITY

| | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| Injury | | 1 | | 1 |
| Fatality | | | | |
| Property Dam. Only | 1 | | | |

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

3. According to the accident records, all three reported accidents at this site occurred at night. In an effort to better identify the alignment of the road, it is recommended that a series of reflectorized delineators (Design C, 4" x 4") be installed on the outside of the curve. The appropriate spacing for these delineators is shown in Figure 1D. It is important to include the more widely spaced reflectors recommended for the tangent sections so that motorists are led into and around the curve.

IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| 1 | ea | Remove Curve Warning Sign | $30 | $ 30 |
| 2 | ea | Install Turn Warning Sign (W1-1) with 25 mph Advisory Speed Plate (W13-1) | $180 | 360 |
| 1 | ea | Remove Slow Sign | $30 | 30 |
| 1 | ea | Install Hill Warning Sign (W7-1) | $105 | 105 |
| 11 | ea | Install Reflectorized Delineators (Design C, 4" x 4") | $18 | 198 |

Total Cost: $723

Benefit/Cost Ratio: 2.6

Long-Term Improvements

The sight distance is limited to 170 feet around the curve at the crest of the hill by the steep bank on the inside shoulder. It is recommended that a portion of this bank be excavated and deposited on the outside of the curve. The cut on the inside shoulder should result in a 6:1 slope for a width of 20 feet. The bank should be shaped at a 1½:1 slope from the bottom of the cut. These improvements will increase sight distance around the corner to approximately 325 feet. The excavated material should be deposited on the outside of the curve and used to level the area, providing a safe overrun for the curve.

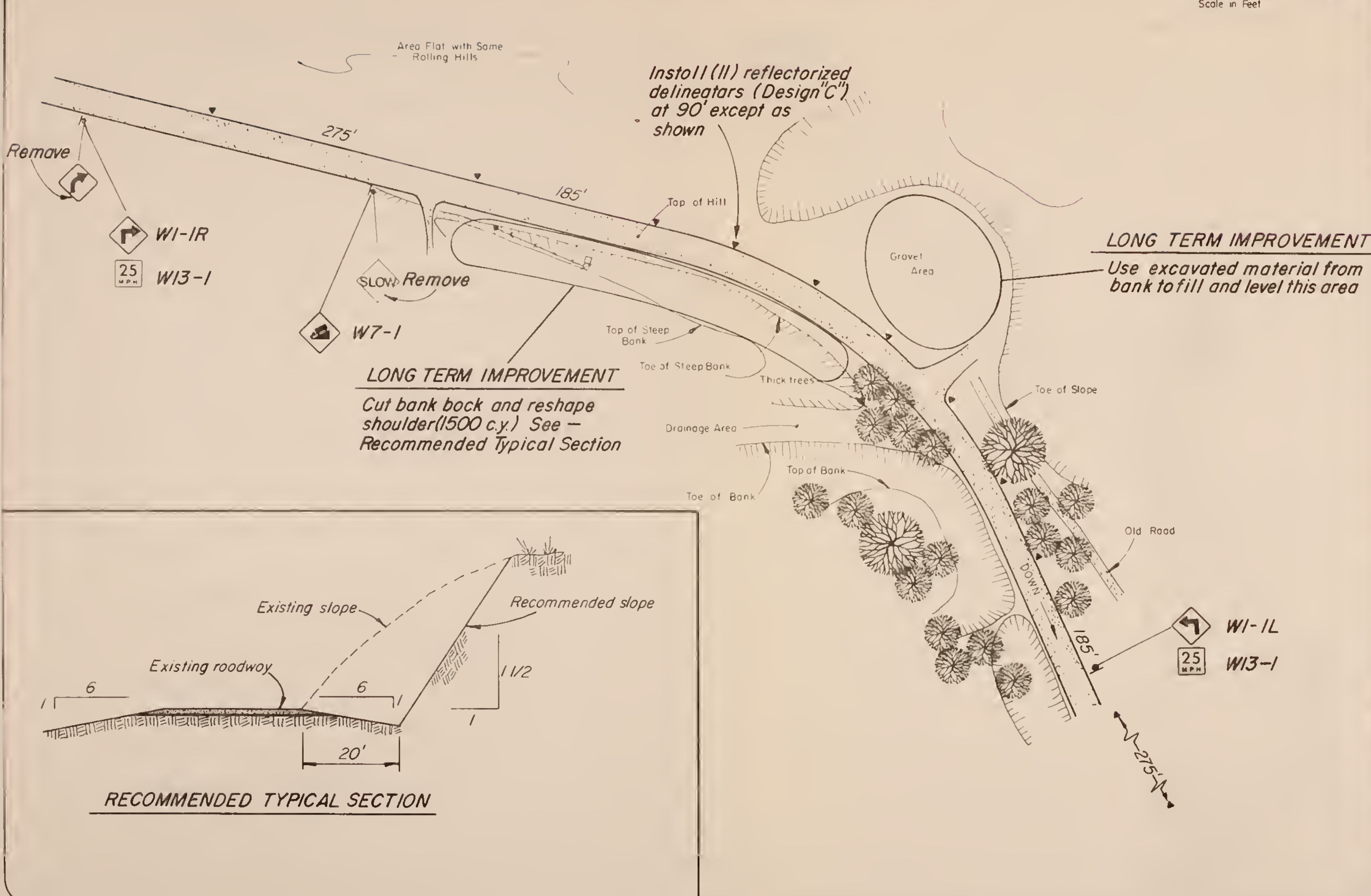
Due to extensive wear and erosion at this site, several additional hazards are present. The deep erosion cuts on the edge of the travelway constitute a serious liability to the County. These dangerous washouts should receive maintenance as soon as possible, or at least be marked so the motorist can avoid the hazard.

The road mix gravel being used on the Cartersville Road tends to lose most of the fines that make up the binder material, leaving large, uncrushed gravel on the road. This material is very unstable and tends to move under wheel loading. Driving on this type of surface is difficult at best on curves and steep hills. Therefore, it is recommended that a uniformly graded crushed aggregate be used in the future in lieu of uncrushed, screened gravel if possible. The interlocking effect of the crushed angular material is more desirable in this particular situation, and will yield a more stable road surface.

LONG-TERM IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| - | Lump Sum | Excavate Material from Bank and Reshape (1,500 cy); Deposit Material on Outside Shoulder and Reshape | - | $4,500 |
| Total Cost: | | | | $4,500 |

# RECOMMENDED IMPROVEMENTS




CARTERSVILLE ROAD·FORSYTH

Site No. 1

Figure No. I·D

Rosebud

## DETERMINATION OF HAZARD INDEX

Site Number *1* Date *December, 1982*

Site Description *Cartersville Road north of Forsyth*

| Indicator | Data Value | Indicator Value | Weight | Partial H.I.'s |
|---|---|---|---|---|
| Number of Accidents | *.75* acc/yr | *22* | x 0.164 = | *3.61* |
| Accident Rate | *32.6* acc/MVE | *100* | x 0.225 = | *22.50* |
| Accident Severity | *13,533* dollars | *72* | x 0.191 = | *13.75* |
| Volume/Capacity Ratio | *.18* | *36* | x 0.082 = | *2.95* |
| Sight Distance Ratio | *.51* (wt. avg.) | *99* | x 0.074 = | *7.33* |
| Driver Expectancy | *3.3* (wt. avg.) | *55* | x 0.149 = | *8.20* |
| Information System Deficiencies | *2.8* (wt. avg.) | *47* | x 0.115 = | *5.41* |

Hazard Index: *63.75*

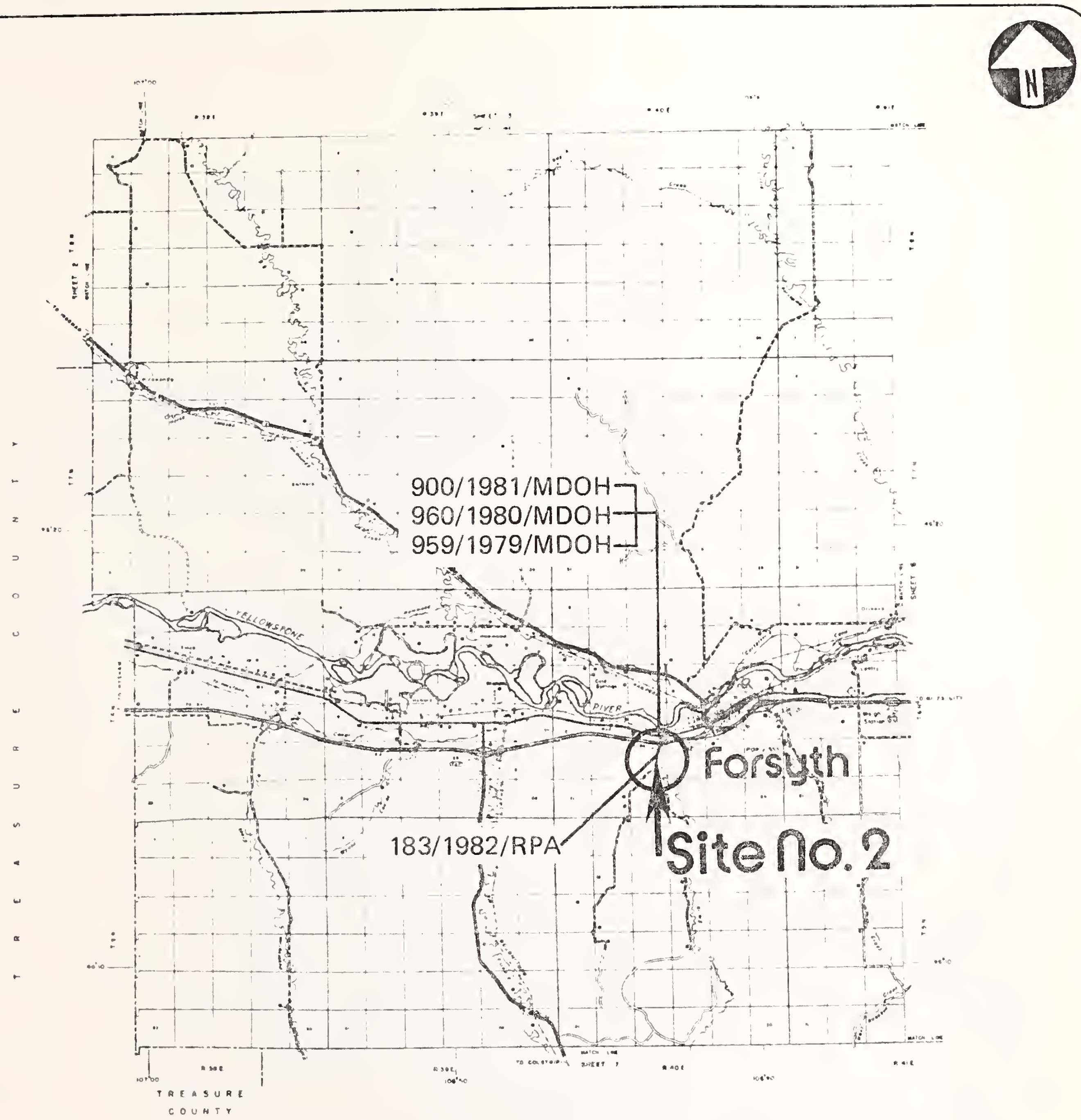
Cost of Recommended Improvements: *$723*

Cost Factor: *87*

Priority Index = Hazard Index x .75 + Cost Factor x .25

*63.75* x .75 + *87* x .25 = *69.56*

# Site No. 2




Average Daily Traffic/Year/Source of Count

183/1982/RPA

# SITE LOCATION

## TRAFFIC COUNTS

## SMITH CREEK ROAD

Figure No.

**2-A**

Rosebud

## SITE #2

### Smith Creek Road at the Golf Course and I-94 Overpass

A. Location

Site #2 is located approximately 1.5 miles west of Forsyth and consists of a series of three turns. The roadway is located in flat to gently rolling terrain adjacent to Smith Creek. The roadway provides public access to the Forsyth Municipal Golf Course and serves agricultural operations south of the community. The location of Site #2 is depicted in Figure 2A.

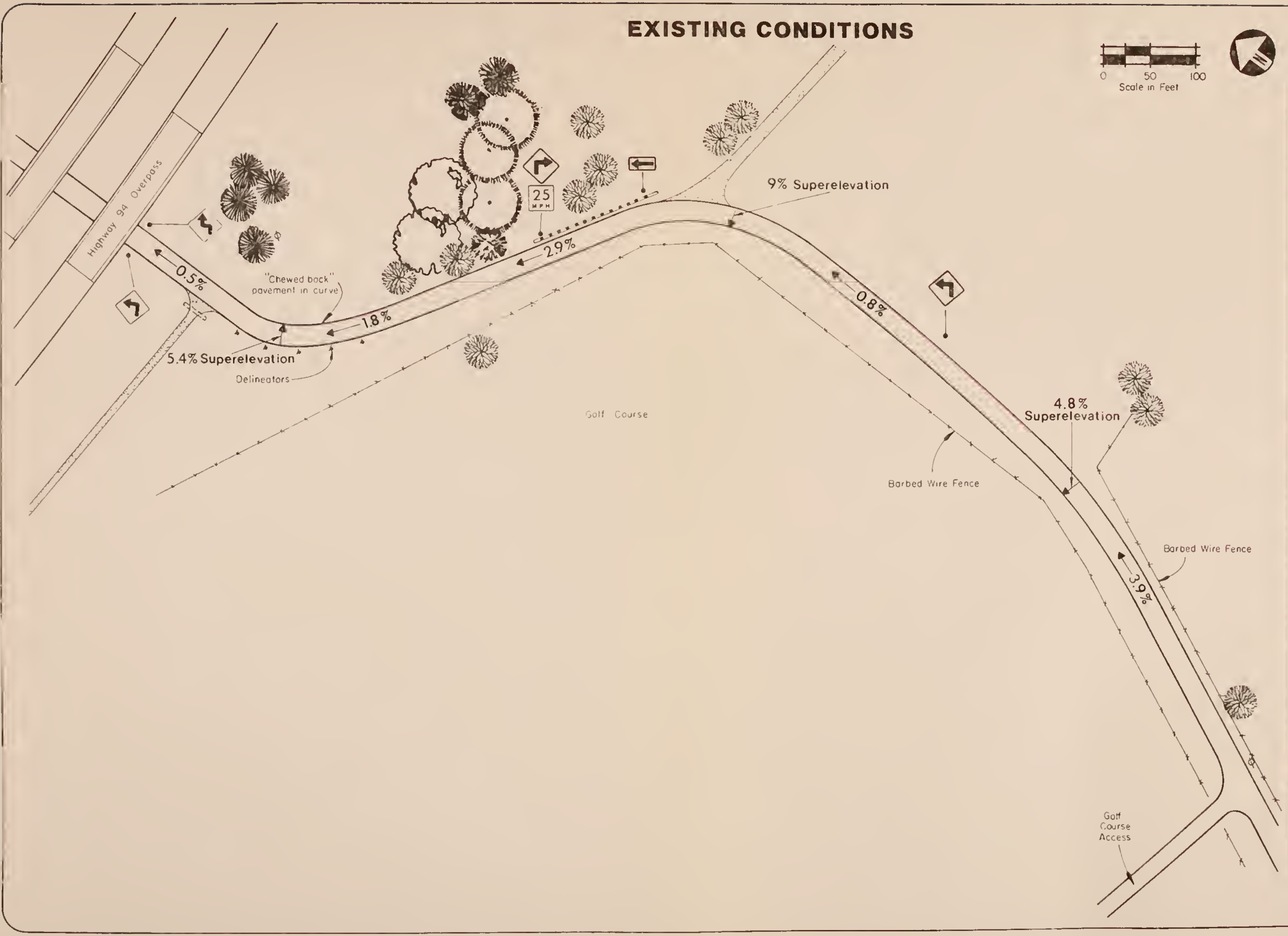
B. Existing Conditions

Smith Creek Road is an asphalt-surfaced roadway with a general width of 24 feet. Pavement width narrows to approximately 20 feet in the first curve south of the I-94 overpass. There is no pavement striping due to a recent chip and seal resurfacing project. Grades through the site are relatively flat, ranging from 0.5 percent to approximately 2 and 3 percent. The first curve south of the overpass has a superelevation of 9 percent. It is apparent from field observations that drivers experience difficulty in negotiating this curve because the pavement surface has been "chewed back" considerably through the inside of the curve.

Most of the signing at the site is intended for northbound drivers, who are faced with more difficult driving maneuvers. This signing includes: 1) a curve warning sign (W1-2L) located 500 feet from the curve; 2) a large directional arrow sign (W1-6) located at the east end of a guard rail section in the curve; and 3) a turn sign (W1-1R) with a 25 mph advisory speed plate, located approximately 200 feet before the next curve. A reverse turn sign (W1-3R) is located at the northern end of the site to give advance notice of the turns under the I-94 overpasses. Information presented to southbound motorists consists of a turn sign (W1-1L) at the extreme northern end of the site and a series of delineators through the first curve in the site. The guard rail that is located between the first and second curves south of the interstate overpass was installed in 1980 in an effort to keep motorists from rolling over the steep embankment adjacent to the roadway. The existing conditions at this site are depicted in Figure 3B and in Plate 3.

Based on 24-hour machine counts of traffic volumes on Smith Creek Road conducted by Robert Peccia & Associates, the present ADT was determined to be 184 vehicles per day. It should be noted that traffic counts were completed in October near the end of the golfing season; traffic volumes would probably be somewhat higher during the summer, especially during mid-week golf league activities and on weekends.

## EXISTING CONDITIONS




SMITH CREEK ROAD

# Site No. 2

Figure No.

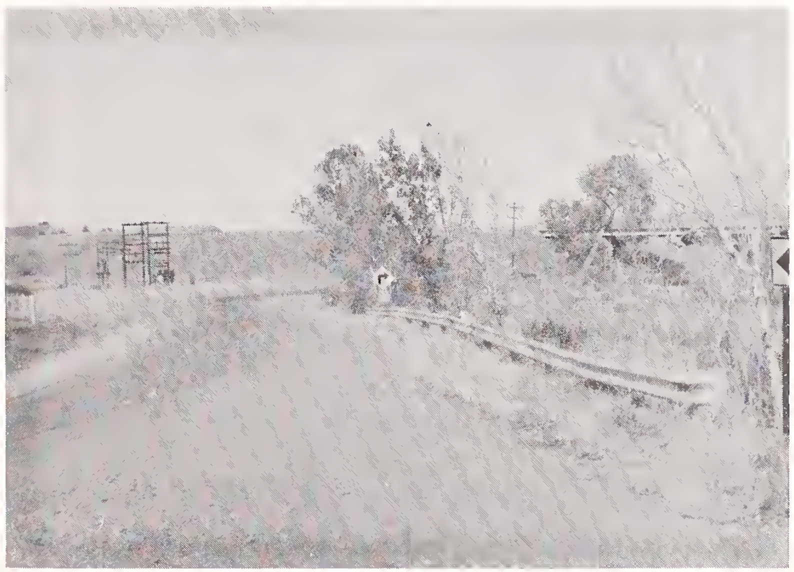
# 2·B

Rosebud

# Existing Site Conditions

View of southern portion of the site. Note curve turn sign and large directional arrow in turn.

View of both reverse curves in the site. Note the deteriorated pavement on the inside of the nearest curve.



View of central portion of the site. Note sight distance limitation resulting from roadside vegetation in northernmost curve. The existing turn sign is mounted below standard height.

View of south approach to the site. Note long tangent section leading into the sharp turn. The majority of the accidents at this site occurred at this turn.

C. Accident History

A total of six accidents were reported at this general location on Smith Creek Road during the four-year study period. Figure 2C depicts the locations and circumstances of these accidents. Five of the six accidents resulted in injuries to a total of seven persons. All of the accident reported at this site occurred at night during clear weather and dry road conditions. Five of the six accidents occurred at the southernmost curve in the site where northbound motorists are required to make a drastic change in driving maneuvers. In addition to the sharp turning movement required at this location, a steep embankment exists adjacent to the roadway and presents motorists with a hazardous situation. Due to the large number of accidents in which vehicles travelled down the embankment, a guard rail was installed as a protective measure in 1980. Since then, no accidents have been reported at this location within the site. The other reported accident at the site occurred in the northernmost curve and involved a loss of control and subsequent collision with an I-94 overpass pier. The major contributing circumstance to the accidents at this site appears to be excessive speed. The series of driving maneuvers required at this site dictates that motorists maintain relatively low travel speeds. Alcohol was also involved in three of the six reported accidents. The accident rate at this site is 22.3 per million vehicles entering. A composite collision diagram is presented in Figure 2C.

D. Recommendations

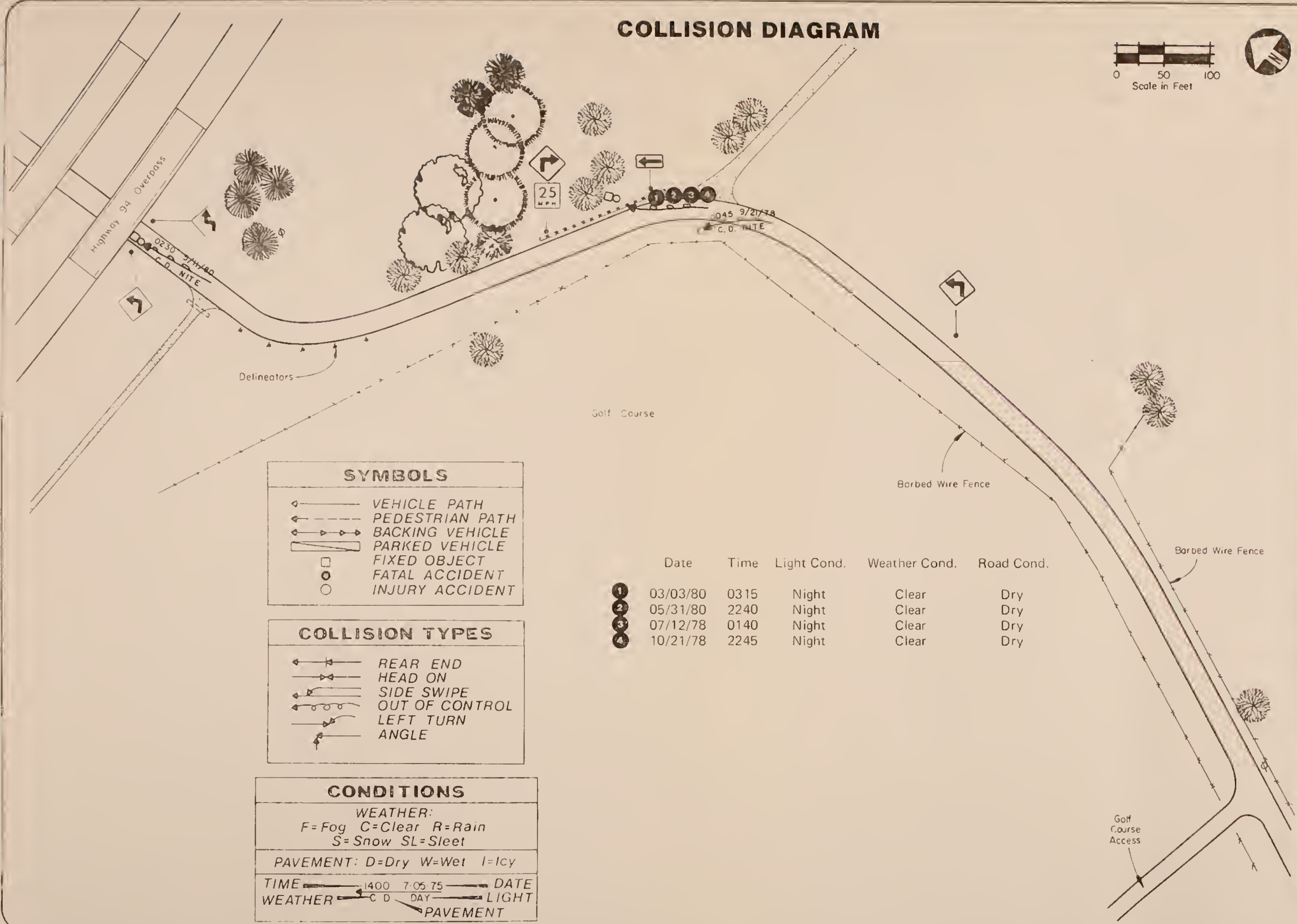
The sharp changes in roadway alignment at this site should be identified more clearly. According to the accident history, northbound motorists have difficulty negotiating this series of curves. It seems that the first curve is often taken at too high a rate of speed, and vehicles are thrown to the outside of the curve against the guard rail. A combination of factors are contributing to this situation, including inadequate superelevation in the curve and insufficient curve identification. The long-term improvements address the recommended reconstruction of the curves' superelevation, while the short-term improvements concentrate on improved signing and delineation. The short-term improvements are as follows:

1. The reverse curves are inappropriately signed, and the through turn warning signs (W1-1) currently being used should be removed. The reverse curve warning sign (W1-3L) is more appropriate and should be posted on both approaches. These signs can be installed on the posts that are being used for the existing turn warning signs.

The maximum safe speed for this combination of curves was determined to be 20 mph, according to a ball bank indicator test performed in the field. Therefore, it is recommended that 20 mph advisory speed plates (W13-1) be installed with the reverse curve warning signs on both approaches.

2. The accident history of this site indicates that most accidents involved northbound vehicles. It is therefore recommended that the curve delineation be improved for both approaches, with extra emphasis on the northbound lane. The existing directional arrow on the outside of the southernmost curve should be removed and a series of chevron warning signs (W1-8) in-

# COLLISION DIAGRAM




| | Date | Time | Light Cond. | Weather Cond. | Road Cond. |
|---|---|---|---|---|---|
| 1 | 03/03/80 | 0315 | Night | Clear | Dry |
| 2 | 05/31/80 | 2240 | Night | Clear | Dry |
| 3 | 07/12/78 | 0140 | Night | Clear | Dry |
| 4 | 10/21/78 | 2245 | Night | Clear | Dry |

Site No. 2
SMITH CREEK ROAD

Figure No. 2·C
Rosebud

# ACCIDENT DATA

*Smith Creek Road at the Golf Course & I-94 Overpass*

SITE NUMBER 2 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

| 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|
| 3 | | 3 | |

NUMBER OF ACCIDENTS BY DAY OF WEEK

| Sun. | Mon. | Tues. | Wed. | Thurs. | Fri. | Sat. |
|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | 1 | | 2 |

NUMBER OF ACCIDENTS BY MONTH

| Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | 2 | | 1 | | 1 | 1 | | |

NUMBER OF ACCIDENTS BY TIME OF DAY

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | 2 | | 1 |

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

| Day-light | Dark | Dawn | Dusk |
|---|---|---|---|
| | 6 | | |

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

| Dry | Wet | Snow | Ice | Other |
|---|---|---|---|---|
| 6 | | | | |

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

| Clear | Rain | Snow | Fog |
|---|---|---|---|
| 6 | | | |

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

| Angle | Turn | Rear End | Fixed Obj. | Ped. | Animal | Side-swipe | Non-Col | Head-on | Backing |
|---|---|---|---|---|---|---|---|---|---|
| | | | 4 | | | | 2 | | |

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

| No Ap. Violation | Drinking | Reckless Driving | Speed | Right-of Way | Improper Passing | Improper Backing | Improper Turning | Other |
|---|---|---|---|---|---|---|---|---|
| 1 | | | 2 | | | | | 3 |

NUMBER OF ACCIDENTS BY SEVERITY

| | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| Injury | 2 | | 3 | |
| Fatality | | | | |
| Property Dam. Only | 1 | | | |

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

3

stalled around the curve. Recommended locations and spacing of these chevrons are shown in Figure 2D. The directional arrow on the east side of the curve should be relocated so that it is clearly visible to the southbound traffic on the curve approach.

3. The delineation of the curve adjacent to the overpass should also be upgraded. A directional arrow (W1-6) should be installed on the west side of the curve and located so it is visible to southbound motorists on the curve approach. A series of chevrons similar to those recommended in item 2 should be located so that motorists can see at least three of the signs at any point on the curve approach. The recommended location and spacing of these chevrons is shown in Figure 2D.

4. The set of reverse curves immediately north of the interstate overpass was briefly investigated to verify the appropriateness of the advance warning signs. It was determined through the use of a ball bank indicator that the maximum safe speed for these reverse curves is 15 mph. It is therefore recommended that 15 mph advisory speed plates be installed to supplement the existing reverse curve warning signs.

## IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| 3 | ea | Remove Turn Warning Signs (W1-1) | $30 | $ 90 |
| 2 | ea | Install Reverse Curve Warning Sign (W1-3L) with 20 mph Advisory Speed Plate (W13-1) | $150 | 300 |
| 1 | ea | Remove and Relocate Directional Arrow (W1-6) | $90 | 90 |
| 1 | ea | Install Directional Arrows (W1-6) | $163 | 163 |
| 10 | ea | Install Chevron Warning Signs (W1-8) | $130 | 1,300 |
| 2 | ea | Install 15 mph Advisory Speed Plate (W13-1) | 50 | 100 |

Total Cost: $2,043

Benefit/Cost Ratio: 6.2

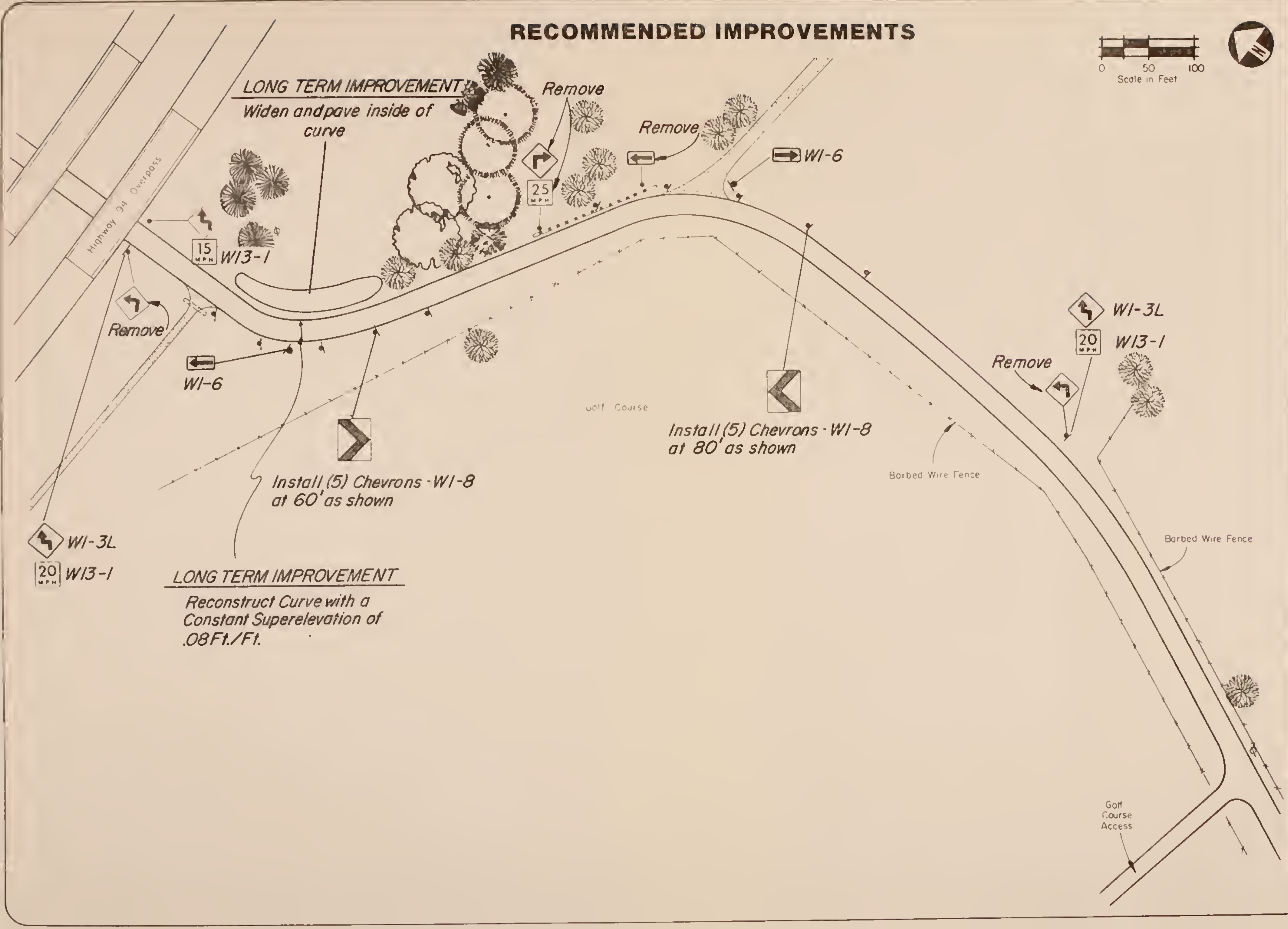
Long-Term Improvements

The inside shoulder of the northernmost curve is deteriorating under the constant wheel loading of traffic. The pavement width narrows from 24 feet on the curve approach to 20 feet in the curve itself. Vehicles are driving on the inside shoulder due to a lack of adequate pavement width. It is therefore recommended that this curve be reconstructed to a uniform width of 24 feet.

The superelevation of the southernmost curve is approximately 9 percent, which is appropriate for the curve although 8 percent is usually considered the maximum design value. The superelevation of the northernmost curve is 5.4 percent. Although the two curves are somewhat similar, motorists must be alert and must change driving characteristics to maintain control because of the difference in the superelevations between the curves. According to the AASHO Design Manual, an 8 percent superelevation is appropriate for this particular curve. It is therefore recommended that the northernmost curve be reconstructed with an 8 percent superelevation. This reconstruction should be accomplished the next time this section of road is resurfaced. In this way, the driving characteristics of the two curves will be the same, and they will be easier for motorists to negotiate.

LONG-TERM IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| - | Lump Sum | Widen Pavement in Curve | - | $1,000 |
| - | Lump Sum | Reconstruct Superelevation | - | 4,000 |
| Total Cost: | | | | $5,000 |




SMITH CREEK ROAD

Site No. 2

Figure No. 2-D

Rosebud

## DETERMINATION OF HAZARD INDEX

Site Number *2* Date *December, 1982*

Site Description *Smith Creek Road*

| Indicator | Data Value | Indicator Value | Weight | Partial H.I.'s |
|---|---|---|---|---|
| Number of Accidents | *1.5* acc/yr | *33* | x 0.164 = | *5.41* |
| Accident Rate | *22.3* acc/MVE | *100* | x 0.225 = | *22.50* |
| Accident Severity | *12,083* dollars | *68* | x 0.191 = | *12.99* |
| Volume/Capacity Ratio | *.17* | *35* | x 0.082 = | *2.87* |
| Sight Distance Ratio | *1.53* (wt. avg.) | *9* | x 0.074 = | *0.67* |
| Driver Expectancy | *4.7* (wt. avg.) | *78* | x 0.149 = | *11.62* |
| Information System Deficiencies | *4.0* (wt. avg.) | *67* | x 0.115 = | *7.71* |

Hazard Index: *63.77*

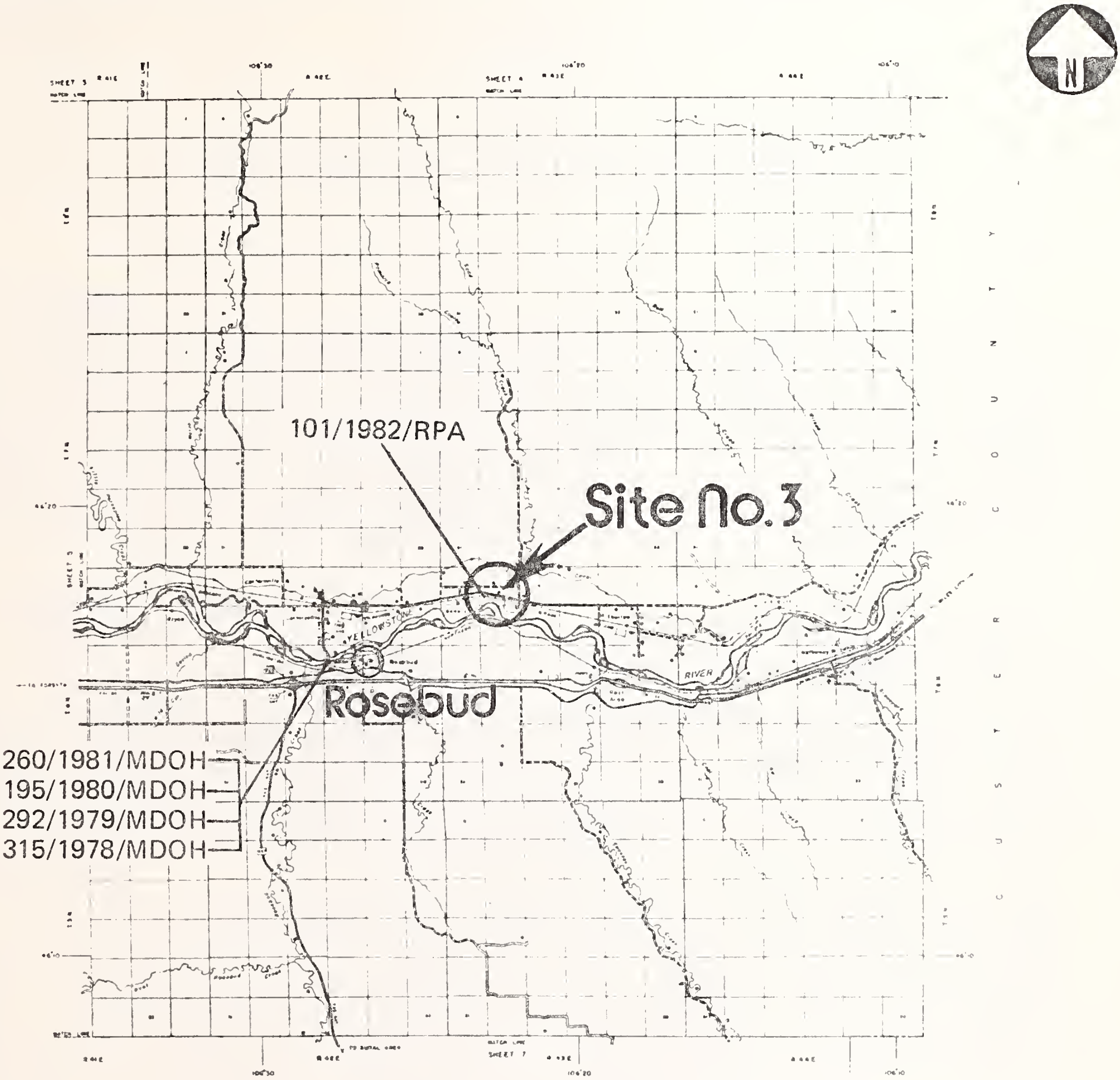
Cost of Recommended Improvements: *$2,043*

Cost Factor: *88*

Priority Index = Hazard Index x .75 + Cost Factor x .25

*63.77* x .75 + *88* x .25 = *69.83*

# Site No. 3




Average Daily Traffic/Year/Source of Count

183/1982/RPA

# SITE LOCATION
# TRAFFIC COUNTS
## SAND CREEK BRIDGE

Figure No.
**3-A**
Rosebud

## SITE #3

### Cartersville Road at the Sand Creek Bridge

A. Location

Site #3 is located approximately 4.5 miles due east of Cartersville, a small community northeast of Rosebud. The site consists of the Sand Creek Bridge and its approaches, and is located midway through a broad, sweeping curve on Cartersville Road. The site is located in a lightly developed agricultural area adjacent to the Yellowstone River. This area is primarily used as pasture land or irrigated for crops such as alfalfa and corn. The location of the Sand Creek Bridge area of Cartersville Road is depicted in Figure 3A.

B. Existing Conditions

Cartersville Road has an unstriped pavement width of approximately 30 feet, and received a chip and seal resurfacing in August of 1982. Grades on both approaches are effectively flat, sloping at 0.1 percent toward the bridge. Superelevation through the site ranges from approximately 4 to 6 percent. Signing at the site is limited to the object markers placed at each end of the bridge; the speed limit through the site is assumed to be 55 mph. Sight distance at the site is virtually unlimited due to the flat terrain and broad curve.

The Sand Creek Bridge, an asphalt-surfaced wooden structure, has a length of 40 feet and a deck width of 28 feet. Based on the Montana Department of Highways Structure Inventory and Appraisal completed in June, 1981, it appears that the bridge is in good condition. The major deficiency listed in this report was a need to clean drains in order to remove water and debris from the surface of the bridge. Existing site conditions are depicted in the site sketch (Figure 3B) and in site photographs (Plate 3).

Twenty-four hour machine traffic counts conducted by Robert Peccia & Associates during October, 1982 were utilized to determine the ADT for this particular location. Based on this data, the average daily traffic was determined to be 101 vehicles.

C. Accident History

A total of three accidents were reported at this location during the study period. One of the accidents resulted in the deaths of two persons, and another was an injury accident resulting in an injury to the driver of the vehicle. The third accident involved a collision with a cow standing in the road. The fatal accident occurred when an eastbound vehicle struck the railing on the Sand Creek Bridge and flipped end over end. Another accident, which occurred in 1978, also involved a vehicle striking the bridge railing. All three of the reported accidents occurred at night during clear


SAND CREEK BRIDGE

Site no. 3

Figure No. 3-B

Rosebud

# Existing Site Conditions

View of bridge and west approach to the site.

View of east approach to the bridge. Note long, straight tangent section leading into the broad curve at the bridge.

View of east approach to the bridge. Note the excellent quality of the chip and seal surface at the site.

Sand Creek Bridge is a wooden structure with a two-inch asphalt surfaced deck. The bridge is 40 feet long and 28 feet wide and is in good structural condition.

Plate 3

weather and dry road conditions. Alcohol was involved in both the fatality and injury accidents that occurred at the site. The accident rate at this site is 20.3 per million vehicles entering (MVE). The accidents reported at this site are depicted in Figure 3C.

D. Recommendations

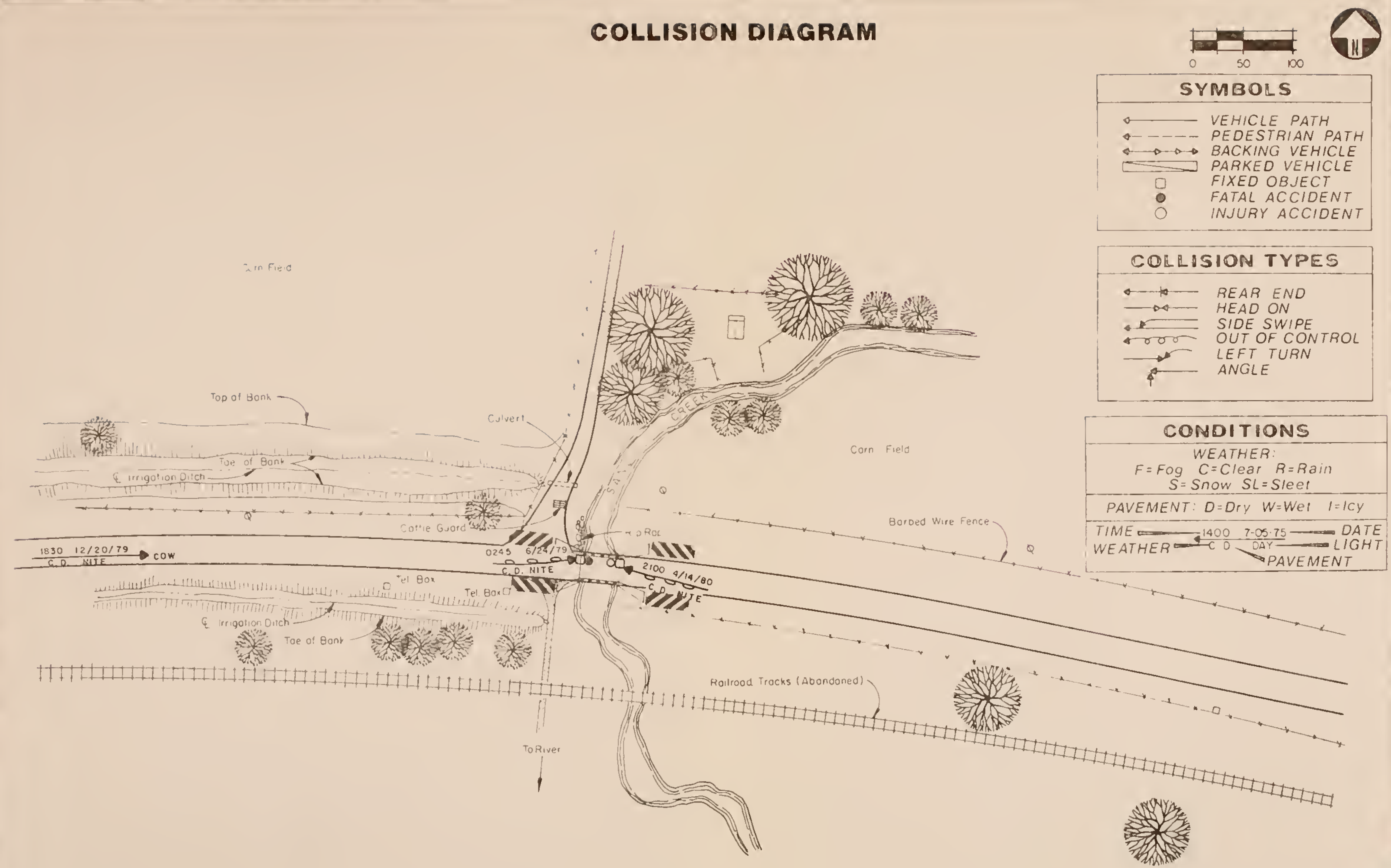
This section of Cartersville Road is in quite good condition and lacks most of the undesirable qualities of most hazardous sites. However, the accident records for this site indicate that both a fatality and an injury accident have occurred during the study period at this location. Both of these accidents occurred as a result of vehicles striking the bridge railing. The bridge is presently signed with Type 3 object markers, and there is only a minor change in alignment at this site. The recommended improvements listed below address additional measures to identify the structure and to safely lead motorists through this site. The short-term improvements adequately address the problems at this site; therefore, no long-term recommendations have been made.

1. The bridge presently has a wooden guard rail that has been hit on several occasions. In both accidents mentioned previously, the vehicles collided with the guard rail. In the case of the fatality accident, the vehicle was not stopped by the wooden guard rail and went off the bridge, hitting the creek bank below. In an effort to minimize the severity of accidents occurring at this bridge, it is recommended that a completely new guard rail system be installed on the bridge and its approaches. A "W"-shaped ribbon steel guard rail should be used on the bridge and extended for a minimum of 30 feet on both approaches. The installation and post spacing should be similar to the guard rail installation outlined in Standard Drawing 89 of the Montana Department of Highways Standard Specifications. The guard rail should be installed with reflectorized panels attached, as shown in Drawing 85 of the same specifications.

2. To identify the approaches to the bridge, a series of reflectorized delineators (Design A, 4" x 4", silver) should be installed. These reflectors should be installed on the righthand side of both approaches, beginning at the end of the guard rail and extending for 700 feet along the approach. The motorists will then be safely led along the approach and across the bridge.

3. Although both approaches to the bridge are 30 feet wide, the bridge itself is only 28 feet wide, and accumulated snow and debris often reduce the actual travelway to 26 feet or less. Therefore, it is recommended that narrow bridge warning signs (W5-2) be installed to identify this situation to approaching motorists. These warning signs should be located 750 feet from the beginning of the bridge on both approaches.

# COLLISION DIAGRAM




SAND CREEK BRIDGE

# Site No. 3

Figure No.
3-C
Rosebud

# ACCIDENT DATA

*Cartersville Road at the Sand Creek Bridge*

SITE NUMBER 3 ACCIDENT PERIOD 1978 – 1981

NUMBER OF ACCIDENTS BY YEAR

| 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|
| | 2 | 1 | |

NUMBER OF ACCIDENTS BY DAY OF WEEK

| Sun. | Mon. | Tues. | Wed. | Thurs. | Fri. | Sat. |
|---|---|---|---|---|---|---|
| 1 | | | | 1 | 1 | |

NUMBER OF ACCIDENTS BY MONTH

| Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | | 1 | | | | | | 1 |

NUMBER OF ACCIDENTS BY TIME OF DAY

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | | | | | | | | | | | 1 | | | 1 | | | |

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

| Day-light | Dark | Dawn | Dusk |
|---|---|---|---|
| | 3 | | |

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

| Dry | Wet | Snow | Ice | Other |
|---|---|---|---|---|
| 3 | | | | |

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

| Clear | Rain | Snow | Fog |
|---|---|---|---|
| 3 | | | |

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

| Angle | Turn | Rear End | Fixed Obj. | Ped. | Animal | Side-swipe | Non-Col | Head-on | Backing |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2 | | 1 | | | | |

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

| No Ap. Violation | Drinking | Reckless Driving | Speed | Right-of Way | Improper Passing | Improper Backing | Improper Turning | Other |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | |

NUMBER OF ACCIDENTS BY SEVERITY

| | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| Injury | | | 1 | |
| Fatality | | 1 | | |
| Property Dam. Only | | 1 | | |

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

2

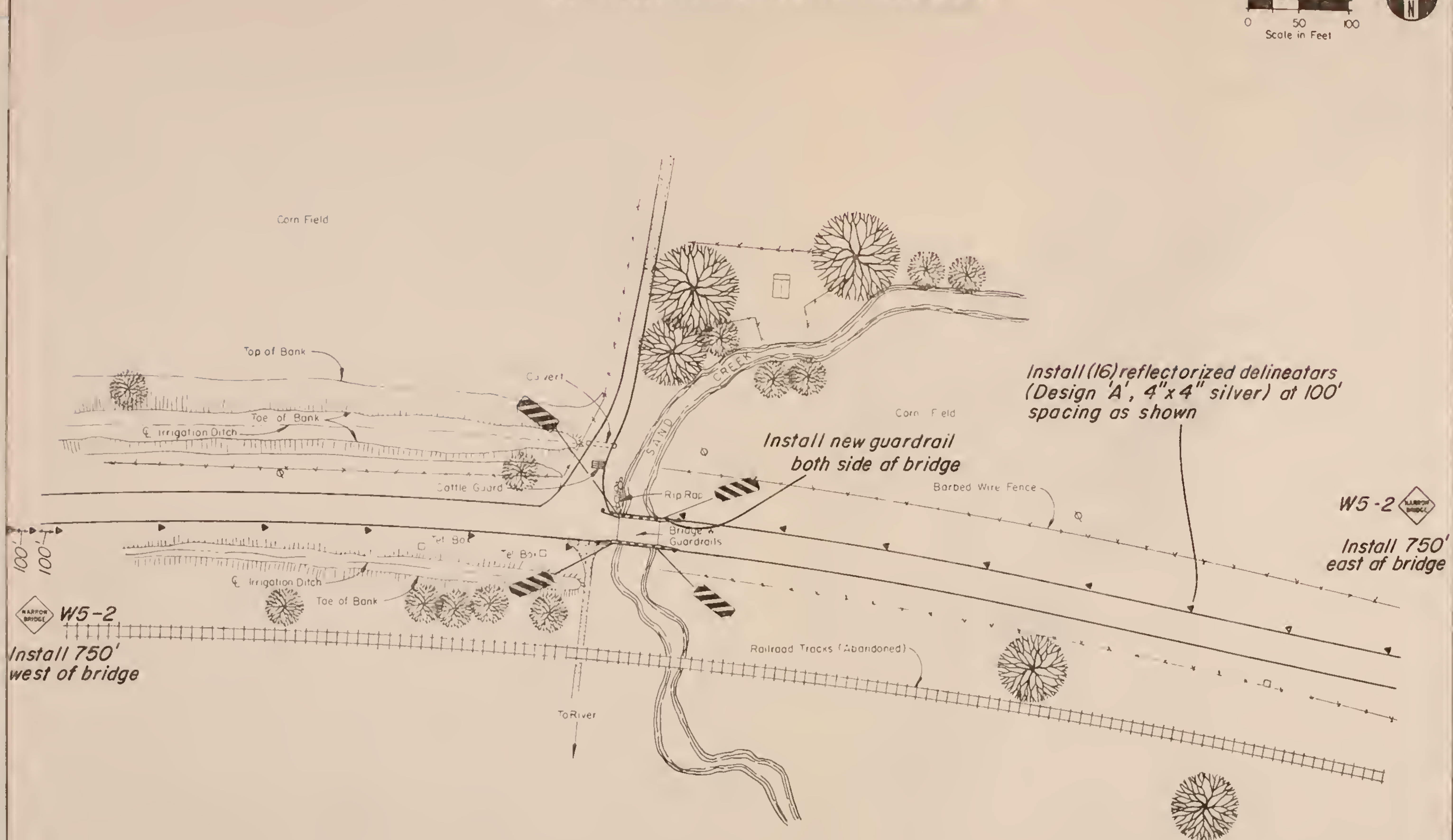
IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| 200 | lf | Install Reflectorized Guard Rail | $9/lf | $1,800 |
| 16 | ea | Install Reflectorized Delineators (Design A, 4" x 4", silver) | $15 | 240 |
| 2 | ea | Install Narrow Bridge Warning Signs (W5-2) | $130 | 260 |

Total Cost: $2,300

Benefit/Cost Ratio: 2.6

# RECOMMENDED IMPROVEMENTS




SAND CREEK BRIDGE

Site No. 3

Figure No. 3-D

Rosebud

## DETERMINATION OF HAZARD INDEX

Site Number *3* Date *December, 1982*

Site Description *Cartersville Road at the Sand Creek Bridge*

| Indicator | Data Value | | Indicator Value | Weight | Partial H.I.'s |
|---|---|---|---|---|---|
| Number of Accidents | *.75* | acc/yr | *22* | x 0.164 = | *3.61* |
| Accident Rate | *20.3* | acc/MVE | *100* | x 0.225 = | *22.50* |
| Accident Severity | *7,600* | dollars | *57* | x 0.191 = | *10.89* |
| Volume/Capacity Ratio | *.02* | | *10* | x 0.082 = | *0.82* |
| Sight Distance Ratio | *2.0* | (wt. avg.) | *0* | x 0.074 = | *0* |
| Driver Expectancy | *1.3* | (wt. avg.) | *22* | x 0.149 = | *3.28* |
| Information System Deficiencies | *1.8* | (wt. avg.) | *30* | x 0.115 = | *3.45* |

Hazard Index: *44.55*

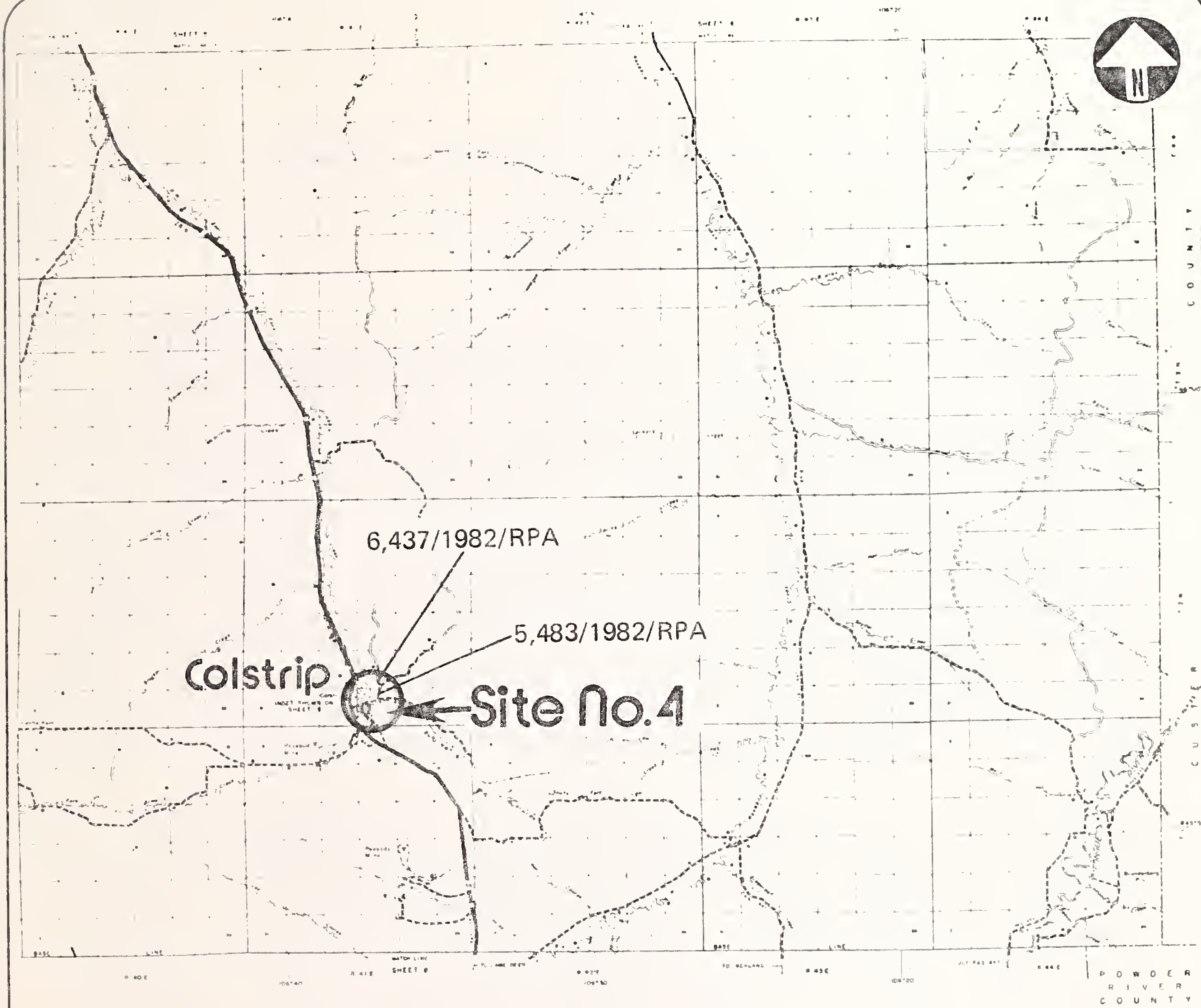
Cost of Recommended Improvements: *$2,300*

Cost Factor: *75*

Priority Index = Hazard Index x .75 + Cost Factor x .25

*44.55* x .75 + *75* x .25 = *52.16*

# Site no.4




Average Daily Traffic/Year/Source of Count

183/1982/RPA

# SITE LOCATION
# TRAFFIC COUNTS
## POWER ROAD & PINE BUTTE DRIVE

Figure No.
**4•A**
Rosebud

SITE #4

Intersection of Power Road and Pine Butte Drive
at Colstrip

A. Location

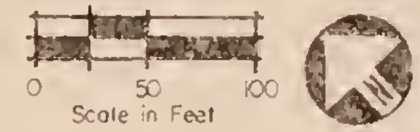
Site #4 is located in gently rolling terrain north of the Colstrip community center approximately .4 miles from the intersection of Montana 39 (FAP 39) with Power Road. The site includes the intersections of Power Road and Pine Butte Drive. Pine Butte Drive provides access to and from the Sweetgrass, Stillwater and Big Timber temporary mobile home neighborhoods, the Pine Butte Elementary School, and the new Colstrip Senior High School, which is presently under construction. Power Road also provides access to residential areas on the east side of Colstrip; however, it appears that the roadway is heavily used by local residents as an alternative to Montana 39 as a route to and from the community center and work sites near the power plants. Construction activities in the Colstrip area are presently nearing peak levels and completion of the power plant projects will result in the departure of significant numbers of workers and their families.

B. Existing Conditions

All approaches to the "T" intersection of Power Road and Pine Butte Drive have striped asphalt pavement surfaces. Power Road varies in width from 48 feet at the intersection to 32 feet on both approaches. Pavement markings delineate two 12-foot driving and turning lanes, and shoulders varying from 4 to 6 feet in width. Pine Butte Drive is 56 feet wide near the intersection and has pavement striping delineating 12-foot- wide driving lanes and 4-foot-wide shoulders. The intersection is also equipped with traffic channelizing islands to channel motorists through the intersection. A painted island is also used on the east leg of Power Road for this purpose. Both Power Road and Pine Butte Drive were reconstructed and paved during 1980. The original island and striping configuration of the intersection proved to be ineffective, and have since been reconstructed. The current configuration of the intersection is depicted in Figure 4B. Grades on Power Road range from 5.2 percent on the hill east of the intersection to 2.8 percent through the intersection. The grade on Pine Butte Drive is approximately 3 percent toward the intersection.

Signing on the east approach to the intersection (Power Road) consists of a "Merge" sign (W4-1) in the merge lane with Pine Butte Drive; a "Yield" sign at the turn; a "Mandatory Turn" sign (R3-7) for traffic in the right lane; and an informational street sign located approximately 500 feet east of the intersection.

# EXISTING CONDITIONS



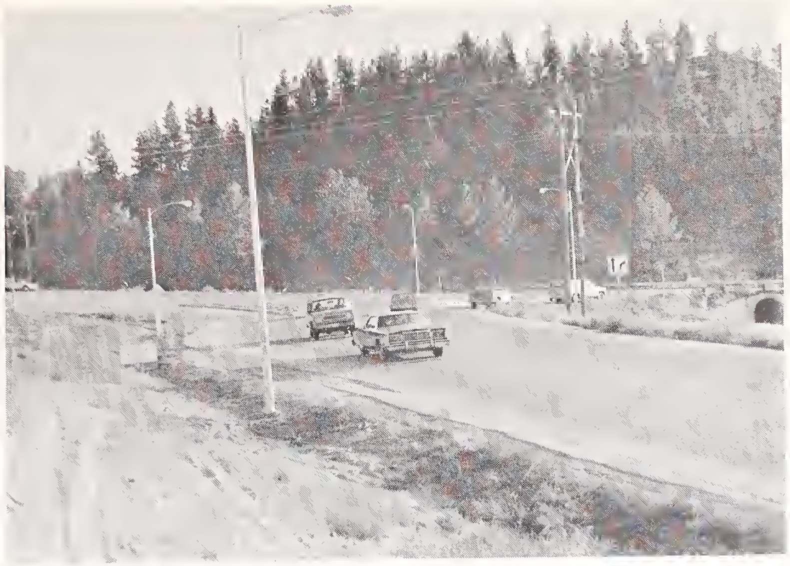


POWER ROAD
PINE BUTTE DRIVE

Site no.4

Figure No.
4-B
Rosebud

# Existing Site Conditions



View of north leg of the intersection (Pine Butte Drive) depicting the existing signing and traffic channelization.

View of intersection from east approach. Note signing, channelization, lighting and delineation at the intersection.

View of west approach to intersection (Power Road). Note pedestrian facilities adjacent to the roadway.

Peak hour traffic at intersection during October, 1982.

Plate 4

Signing on the west approach consists of a double turn sign located 200 feet from the intersection; an informational street sign; a sign warning of speed bumps located to the east on Power Road; and a side road sign (W2-2) located approximately 500 feet from the intersection. The posted speed limit in the vicinity of the intersection is 35 mph.

Signing on Pine Butte Drive includes a yield sign and a stop sign located at the intersection to guide drivers attempting to execute right or left turns; a double turn sign (R3-8) installed about 150 feet from the intersection; and a stop ahead sign (W3-1a) located 650 feet from the intersection. The posted speed limit is 35 mph in the vicinity of the intersection.

The intersection is also extensively lighted, and reflectorized delineators have been used to effectively identify roadway edges on all approaches. Existing site conditions are depicted in the photographs contained in Plate 4 and in the site sketch (Figure 4B).

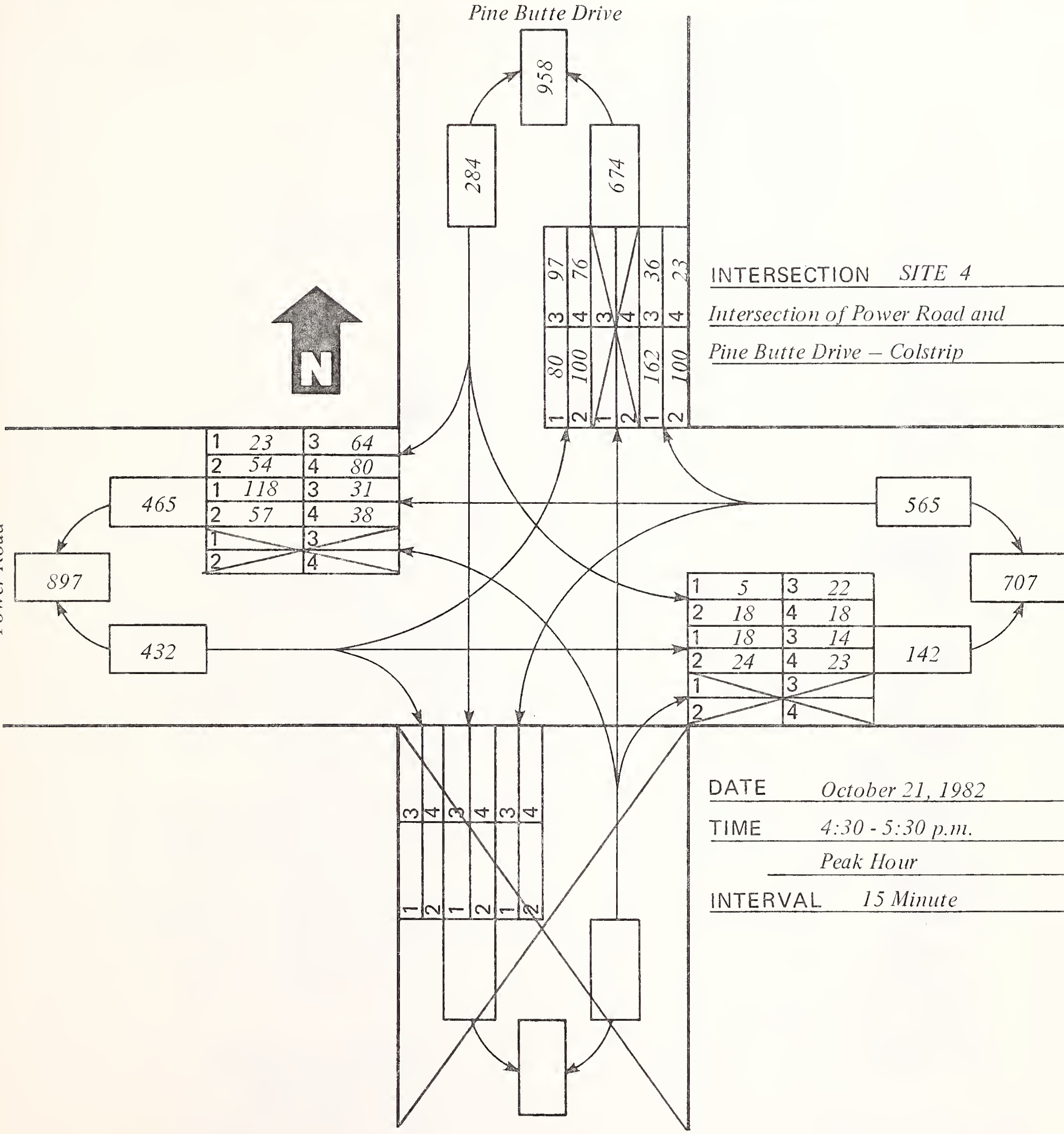
Traffic at the site was documented by Robert Peccia & Associates during October, 1982 through the collection of 24-hour machine counts and peak hour turning movements. Based on this data, the average daily traffic on Power Road and Pine Butte Drive is estimated to be 5,483 and 6,437 vehicles per day, respectively. These traffic volumes reflect the peak or near peak period of construction activities at the new power plants at Colstrip. Traffic volumes will decrease as construction is completed, and should stabilize by the mid 1980's when both plants are operating. The peak hour turning movements at this intersection are summarized in the diagram contained in this site analysis. It should be noted that traffic data was obtained at a time when the railroad crossing at the north edge of Colstrip was closed and the only outlet for traffic on Pine Butte Drive was at the Power Road intersection. Traffic should decrease noticeably when the crossing is reopened.

## C. Accident History

A total of two accidents were reported at this site during the four-year study period extending from January, 1978 through December, 1981. Both of these accidents occurred during 1981. The accidents occurred at night during icy road conditions and resulted in injuries to two persons. One of the accidents occurred as a westbound driver on Power Road lost control on the ice and hit the guard rail on the west approach to the intersection. The other 1981 accident was a head-on collision which occurred north of the intersection on Pine Butte Drive. This collision resulted from a loss of control by the southbound driver on an icy curve with a slight grade. Alcohol was involved in one of the two accidents at the site. The accident rate at this site is 0.6 accidents per million vehicles entering (MVE). Figure 4C depicts the accidents reported at this site during the study period.

Reconstruction at Site #4 in 1980 significantly changed the character of this site. Due to the required consistency in analysis procedures, however, it is necessary to include the years from 1978 through 1980 even though site characteristics were completely different. In order to obtain more insight into site deficiencies or driver tendencies, 1982 reported accidents were revised in the analysis. Three accidents have been reported to date during 1982 at

# TURNING MOVEMENTS




INTERSECTION *SITE 4*

*Intersection of Power Road and*

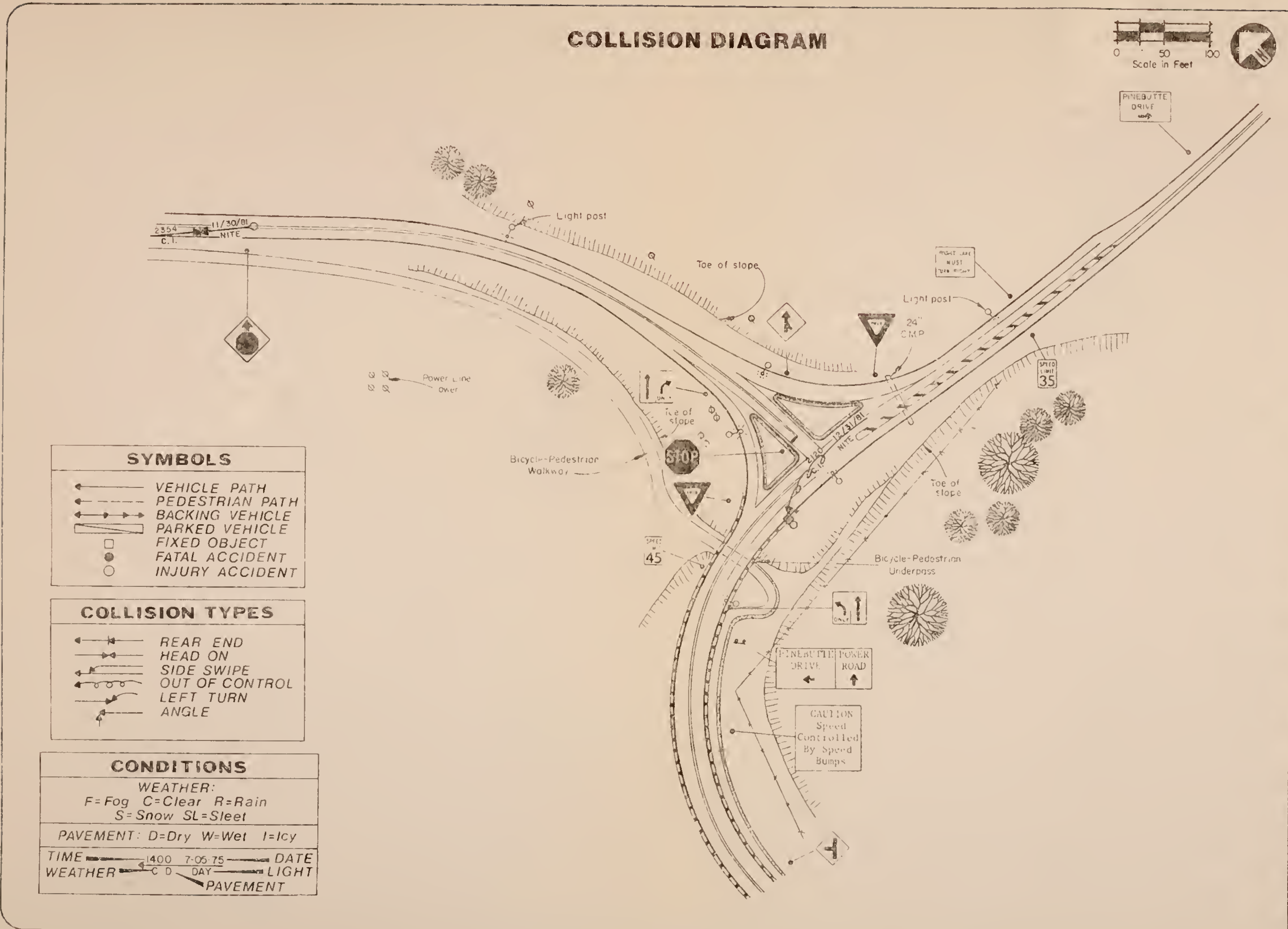
*Pine Butte Drive – Colstrip*

DATE *October 21, 1982*

TIME *4:30 - 5:30 p.m.*

*Peak Hour*

INTERVAL *15 Minute*




POWER ROAD
PINE BUTTE DRIVE

Site no. 4

Figure No.
4-C
Rosebud

# ACCIDENT DATA

*Intersection of Power Road and Pine Butte Drive at Colstrip*

SITE NUMBER 4 ACCIDENT PERIOD 1978 – 1981*

NUMBER OF ACCIDENTS BY YEAR

| 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|
| | | | 2 |

NUMBER OF ACCIDENTS BY DAY OF WEEK

| Sun. | Mon. | Tues. | Wed. | Thurs. | Fri. | Sat. |
|---|---|---|---|---|---|---|
| | 1 | | | 1 | | |

NUMBER OF ACCIDENTS BY MONTH

| Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 1 |

NUMBER OF ACCIDENTS BY TIME OF DAY

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | 1 | | 1 | |

NUMBER OF ACCIDENTS BY LIGHT CONDITIONS

| Day-light | Dark | Dawn | Dusk |
|---|---|---|---|
| | 2 | | |

NUMBER OF ACCIDENTS BY ROAD CONDITIONS

| Dry | Wet | Snow | Ice | Other |
|---|---|---|---|---|
| | | | 2 | |

NUMBER OF ACCIDENTS BY WEATHER CONDITIONS

| Clear | Rain | Snow | Fog |
|---|---|---|---|
| 2 | | | |

NUMBER OF ACCIDENTS BY ACCIDENT TYPE

| Angle | Turn | Rear End | Fixed Obj. | Ped. | Animal | Side-swipe | Non-Col | Head-on | Backing |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | | | | | 1 | |

NUMBER OF ACCIDENTS BY POSSIBLE VIOLATION

| No Ap. Violation | Drinking | Reckless Driving | Speed | Right-of Way | Improper Passing | Improper Backing | Improper Turning | Other |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | | | | | | |

NUMBER OF ACCIDENTS BY SEVERITY

| | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| Injury | | | | 2 |
| Fatality | | | | |
| Property Dam. Only | | | | |

NUMBER OF ACCIDENTS ALCOHOL INVOLVED

| |
|---|
| 1 |

* *Roadways significantly improved during 1980-1981; gravel surface prior to improvements.*

this site, none of which resulted in injuries. Two of the accidents resulted from a loss of control by motorists traveling on snowy and icy roads. Two accidents occurred on Pine Butte Drive and were sideswipe or angle collisions. The other 1982 accident occurred when a westbound driver on Power Road attempted to turn right onto Pine Butte Drive, lost control, slid into a sign and came to rest on one of the traffic islands. It appears that slippery road conditions make the curves and grades at this site difficult to negotiate.

D. Recommendations

This intersection was paved in 1980 and redesigned in 1981; so only one year of accident history is pertinent for the present geometric configuration. Therefore, during the field investigation the traffic characteristics were observed, and the recommended improvements are partially based on these observations. Due to the nature of the Colstrip area and the projected fluctuations in population, no long-term improvements have been recommended. Instead, it is recommended that a supplemental engineering investigation into possible long-term improvements be performed after the population of Colstrip has stabilized and three to four years of accident history is available for analysis. In the meantime, the following short-term improvements address the existing signing and pavement markings.

1. The traffic approaching the intersection from the east on Power Road descends a five percent grade, and excessive speed is often a problem for vehicles entering the intersection from this approach. At present, the speed limit on the east approach is 35 mph. It is recommended that a 35 mph speed limit sign (R2-1) be installed at the crest of the hill on the east approach to allow westbound traffic more time to slow down for the intersection.

2. All three intersection approaches have special lane uses and are signed adequately. In an effort to improve the traffic flow characteristics and minimize confusion, it is recommended that lane use pavement marking symbols be installed on all approaches.

3. During the field observations, it was noted that several vehicles skidded while performing a right turn from the right turn lane on the east approach. Although the right turn ramp is more than 12 feet wide, vehicles often travel on the unpaved shoulder on the inside of the curve, usually as a result of excessive speed. Since the shoulder drops off, motorists have a tendency to stay to the inside of the curve, driving on the edge of the shoulder in an effort to gain additional superelevation. Those vehicles observed traveling too fast on the ramp approach did not hold to the inside edge of the curve and often had difficulty negotiating the curve.

A vehicle equipped with a ball bank indicator was used to determine that 15 mph is the maximum safe speed for the right turn ramp. It is recommended that a 15 mph ramp advisory speed sign (W13-3) be installed on the east approach. This sign should be located approximately 250 feet east of the beginning of the curve.

Due to the tendency of most drivers to travel on the inside edge of the curve, it is also recommended that the roadway be widened by paving a two-foot strip on the inside shoulder.

By implementing these recommendations, vehicles travelling through this curve should be able to do so without loss of control. After implementing the recommended signing, if the average approach speed continues to exceed 15 mph, it may be necessary to increase the curve's superelevation.

4. The existing signing for the right turn movement on the east approach should be modified by removing the merge warning sign (W4-1) and replacing it with a new yield sign (R1-2). This yield sign should be 36" x 36" x 36" and should be installed instead of the present merge sign, which is undersized and incorrectly located.

5. During the peak hour at this intersection, the merge situation of northbound traffic on the north approach becomes a problem. Ramp traffic tends to force the merge and often takes the right-of-way from the through traffic. This situation is caused by excessive ramp speeds and the lack of an adequate merge lane. Effective signing should remedy most of this problem; but if the forced merge situation continues after the recommended signing has been installed, it may be necessary to widen the northbound lane to provide a 200-foot merge lane. This improvement is only recommended if the signing changes fail to produce the desired results.

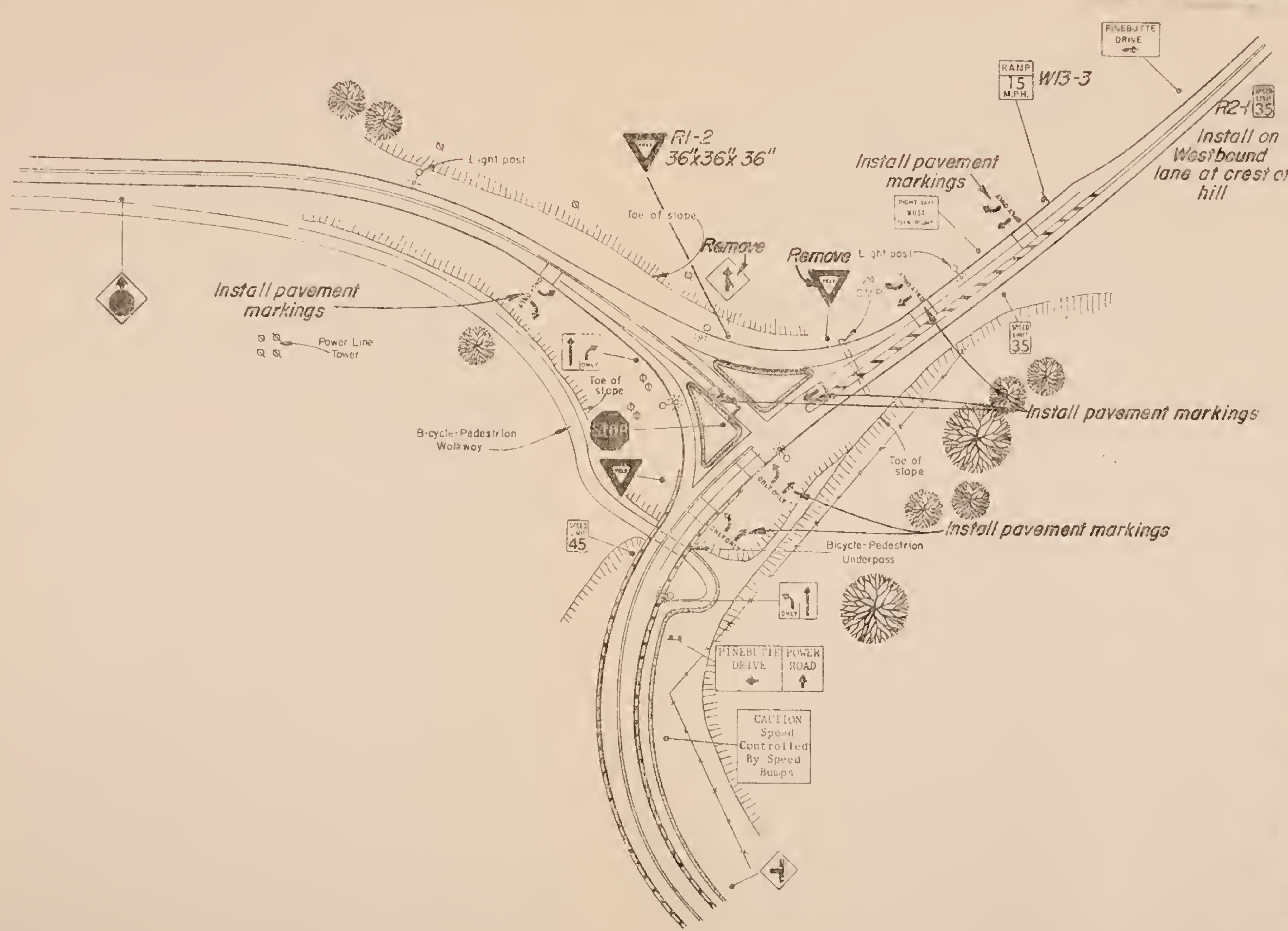
IMPROVEMENT COST ESTIMATE

| Quantity | Unit | Item Description | Unit Price | Total Price |
|---|---|---|---|---|
| 1 | ea | Install 35 mph Speed Limit Sign (R2-1) | $130 | $130 |
| 135 | sf | Install Plastic Pavement Markings (Symbols) | $5/sf | 675 |
| 1 | ea | Install 15 mph Ramp Advisory Speed Sign (W13-3) | $300 | 300 |
| - | Lump Sum | Pavement Widening | - | 750 |
| 1 | ea | Remove Yield Sign (R2-1) | $35 | 35 |
| 1 | ea | Remove Merge Sign (W4-1) | $35 | 35 |
| 1 | ea | Install Yield Sign (R2-1) (36" x 36" x 36") | $100 | 100 |

Total Cost: $2,025

Benefit/Cost Ratio: 2.8

# RECOMMENDED IMPROVEMENTS




POWER ROAD
PINE BUTTE DRIVE

Site No. 4

Figure No.
4-D
Rosebud

DETERMINATION OF HAZARD INDEX

Site Number *4* Date *December, 1982*

Site Description *Power Road and Pine Butte Drive - Colstrip*

| Indicator | Data Value | | Indicator Value | Weight | Partial H.I.'s |
|---|---|---|---|---|---|
| Number of Accidents | *2.0* | acc/yr | *38* | x 0.164 = | *6.23* |
| Accident Rate | *0.6* | acc/MVE | *20* | x 0.225 = | *4.50* |
| Accident Severity | *13,300* | dollars | *72* | x 0.191 = | *13.75* |
| Volume/Capacity Ratio | *.31* | | *48* | x 0.082 = | *3.94* |
| Sight Distance Ratio | *.92* | (wt. avg.) | *35* | x 0.074 = | *2.59* |
| Driver Expectancy | *3.0* | (wt. avg.) | *50* | x 0.149 = | *7.45* |
| Information System Deficiencies | *1.5* | (wt. avg.) | *25* | x 0.115 = | *2.88* |

Hazard Index: *41.34*

Cost of Recommended Improvements: *$2,025*

Cost Factor: *100*

Priority Index = Hazard Index x .75 + Cost Factor x .25

*41.34* x .75 + *100* x .25 = *56.01*

# CHAPTER V

# BIBLIOGRAPHY

# BIBLIOGRAPHY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# CHAPTER VI

# APPENDIX

DETERMINATION OF HAZARD INDEX

Site Number ____________________ Date ____________________

Site Description ________________________________________

| Indicator | Data Value | Indicator Value | Weight | Partial H.I.'s |
|---|---|---|---|---|
| Number of Accidents | ________ acc/yr | ________ | x 0.164 = | ________ |
| Accident Rate | ________ acc/MVE | ________ | x 0.225 = | ________ |
| Accident Severity | ________ dollars | ________ | x 0.191 = | ________ |
| Volume/Capacity Ratio | ________ | ________ | x 0.082 = | ________ |
| Sight Distance Ratio | ________ (wt. avg.) | ________ | x 0.074 = | ________ |
| Driver Expectancy | ________ (wt. avg.) | ________ | x 0.149 = | ________ |
| Information System Deficiencies | ________ (wt. avg.) | ________ | x 0.115 = | ________ |

Hazard Index: ____________________

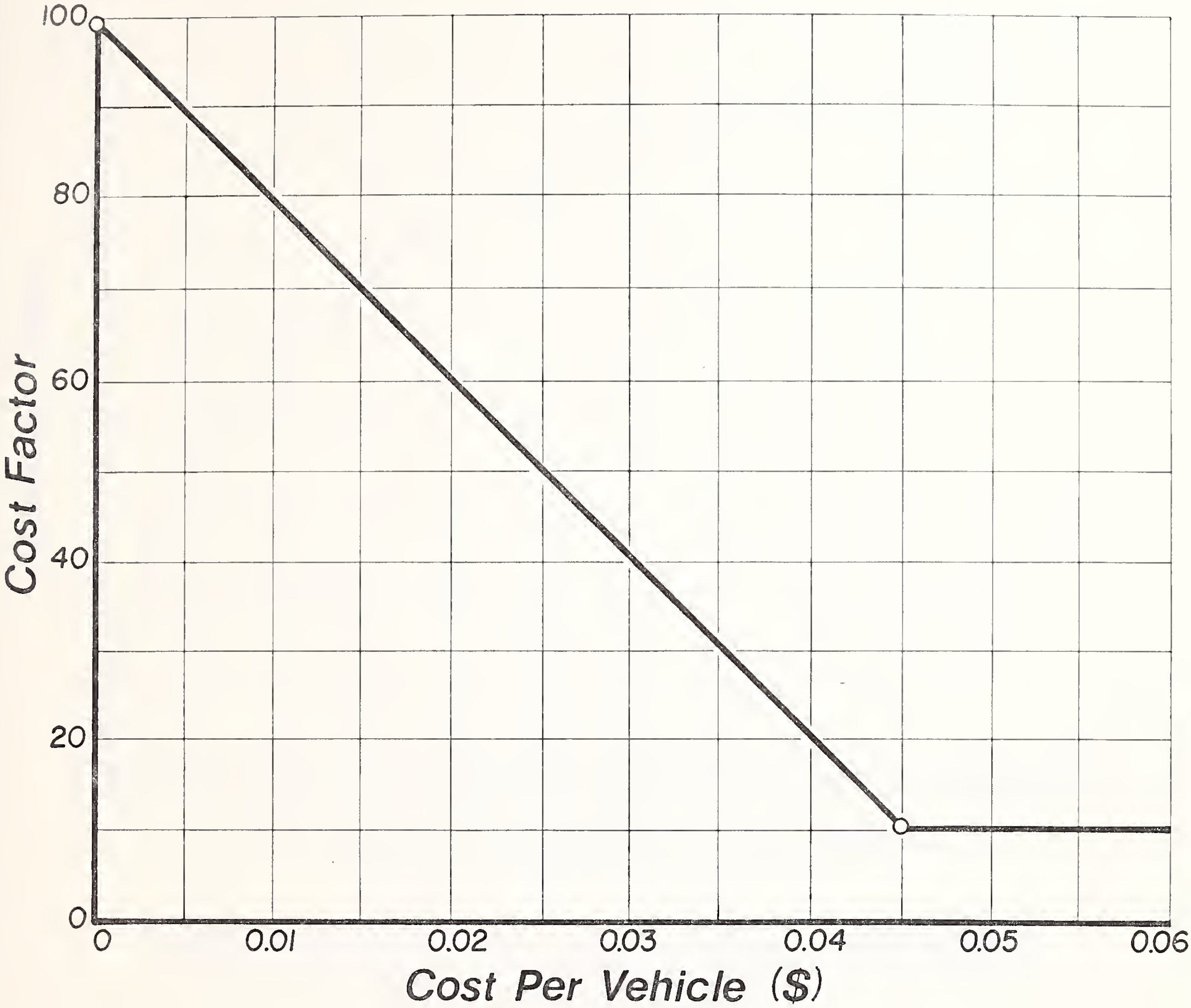
Cost of Recommended Improvements: ____________________

Cost Factor: ____________________

Priority Index = Hazard Index x .75 + Cost Factor x .25

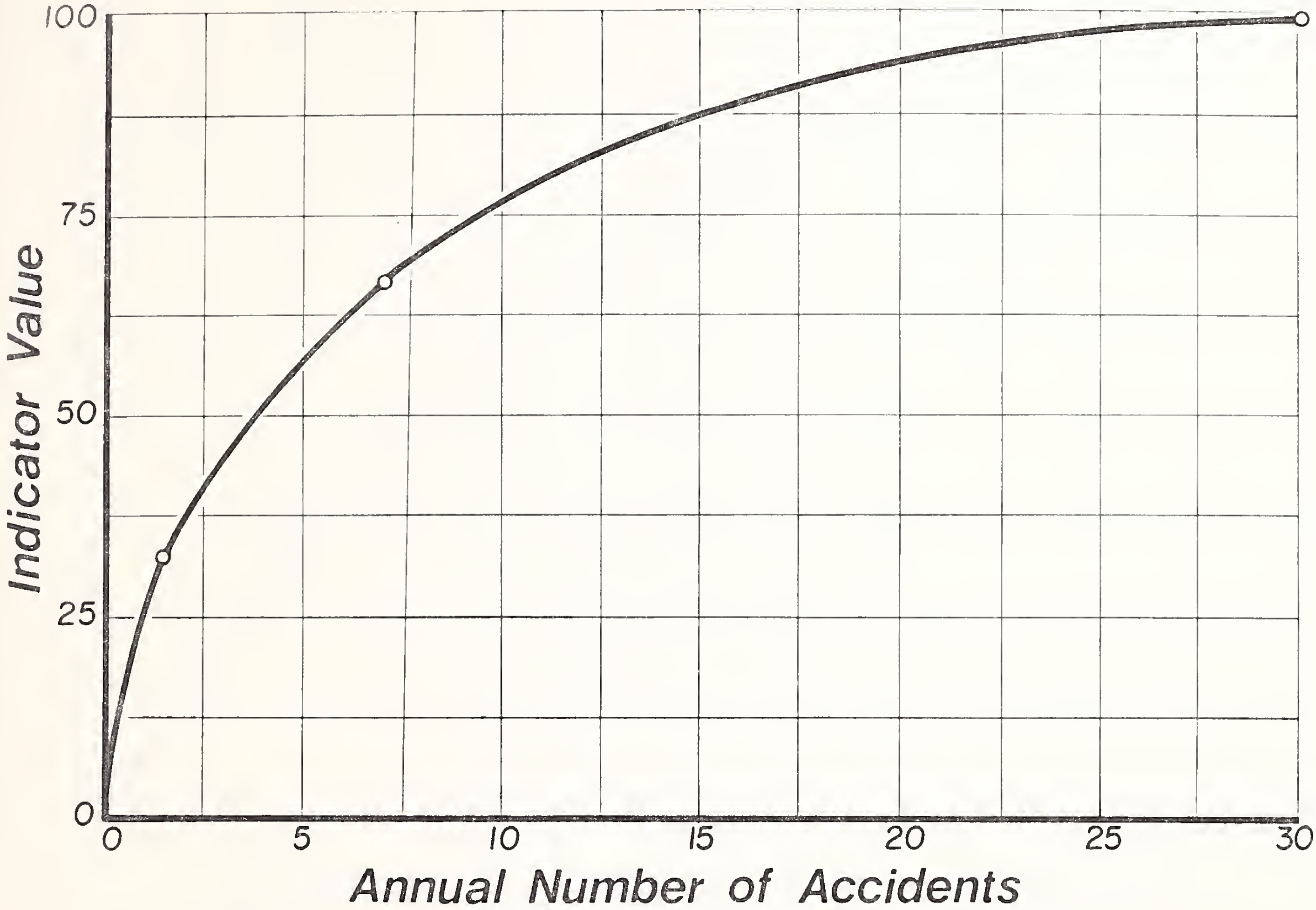
________ x .75 + ________ x .25 = ________

FIGURE A1



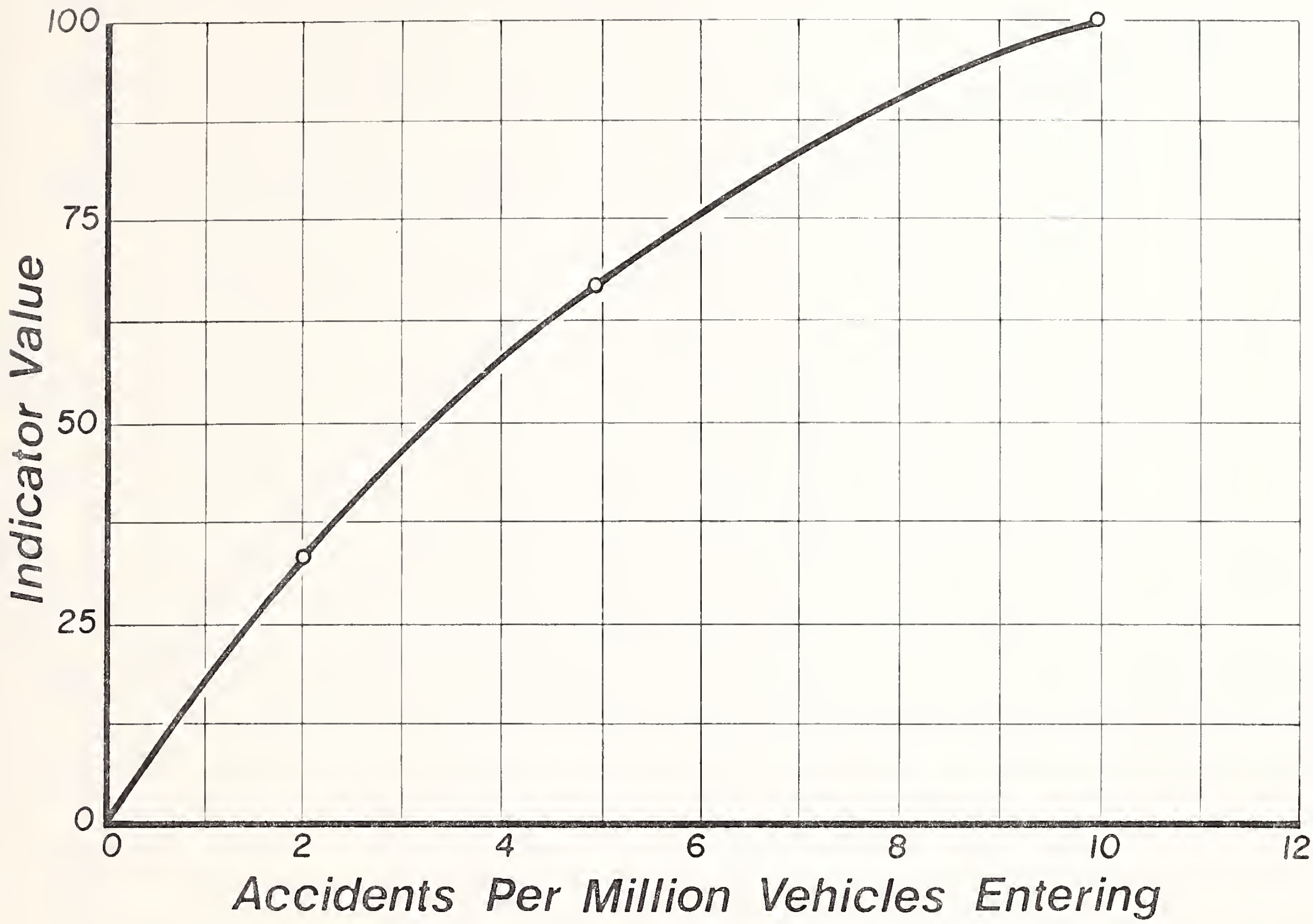

FORM FOR DETERMINATION OF COST FACTOR

FIGURE A2



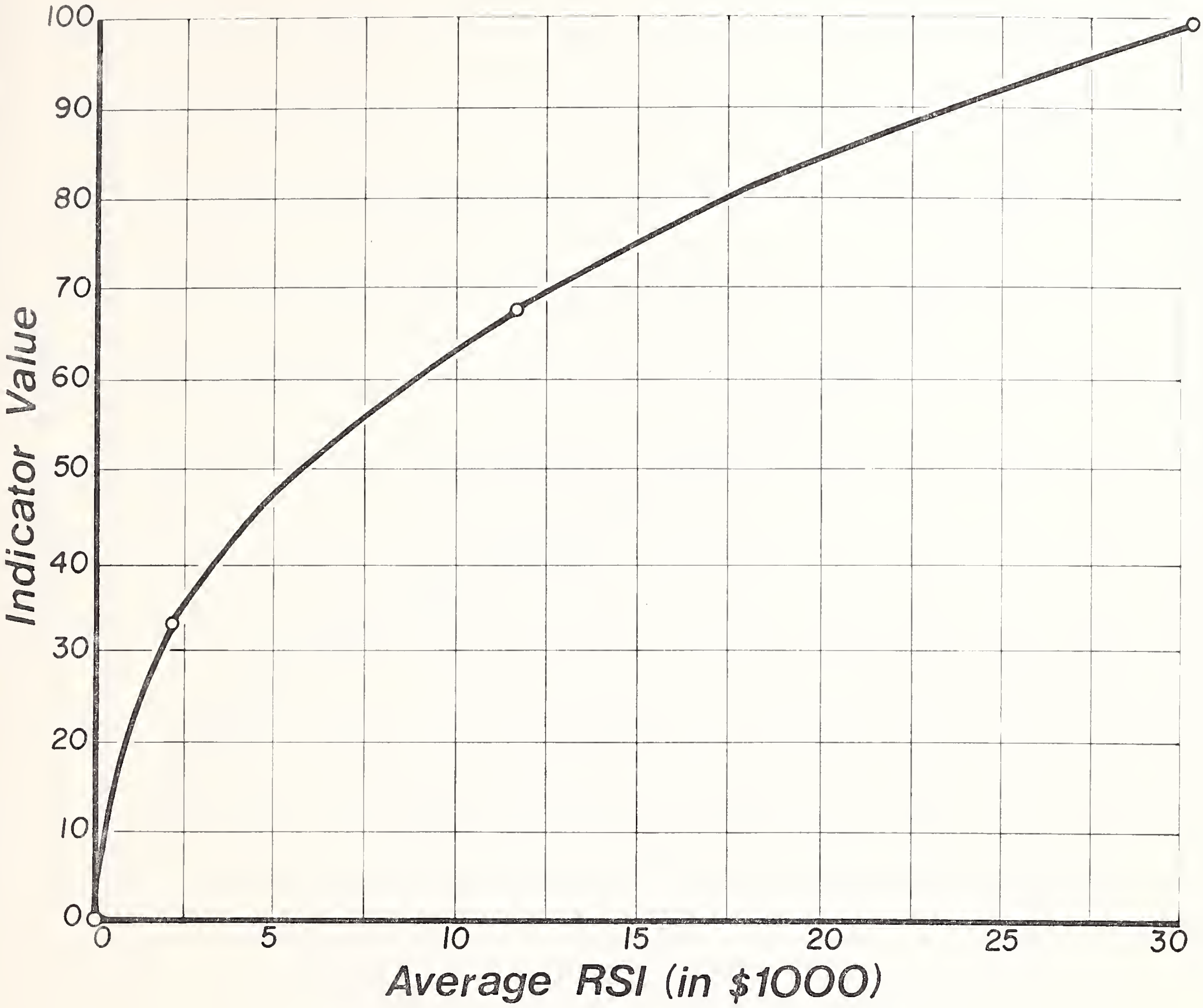

## INDICATOR VALUES FOR NUMBER OF ACCIDENTS

FIGURE A3



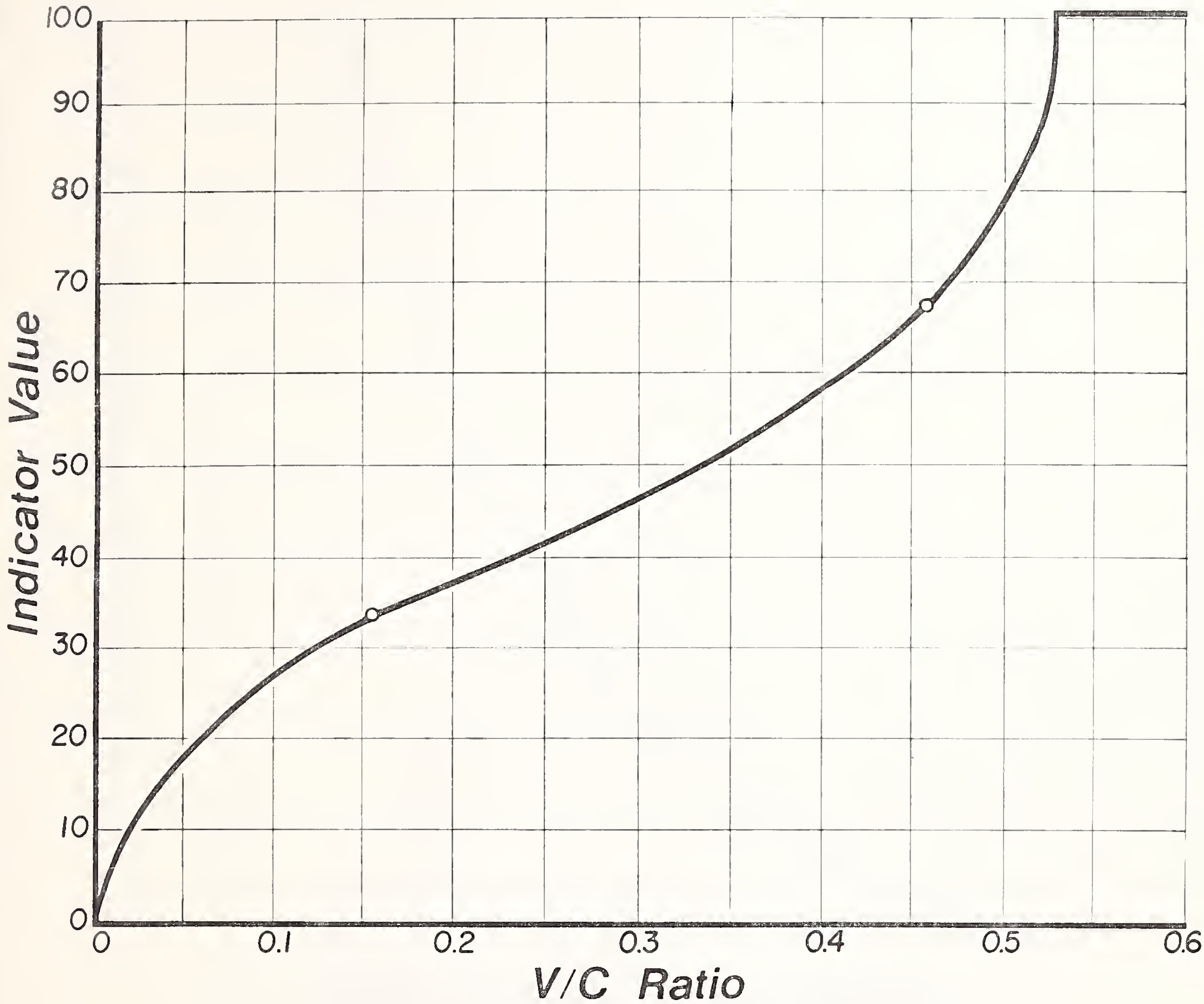

INDICATOR VALUES FOR ACCIDENT RATE

FIGURE A4



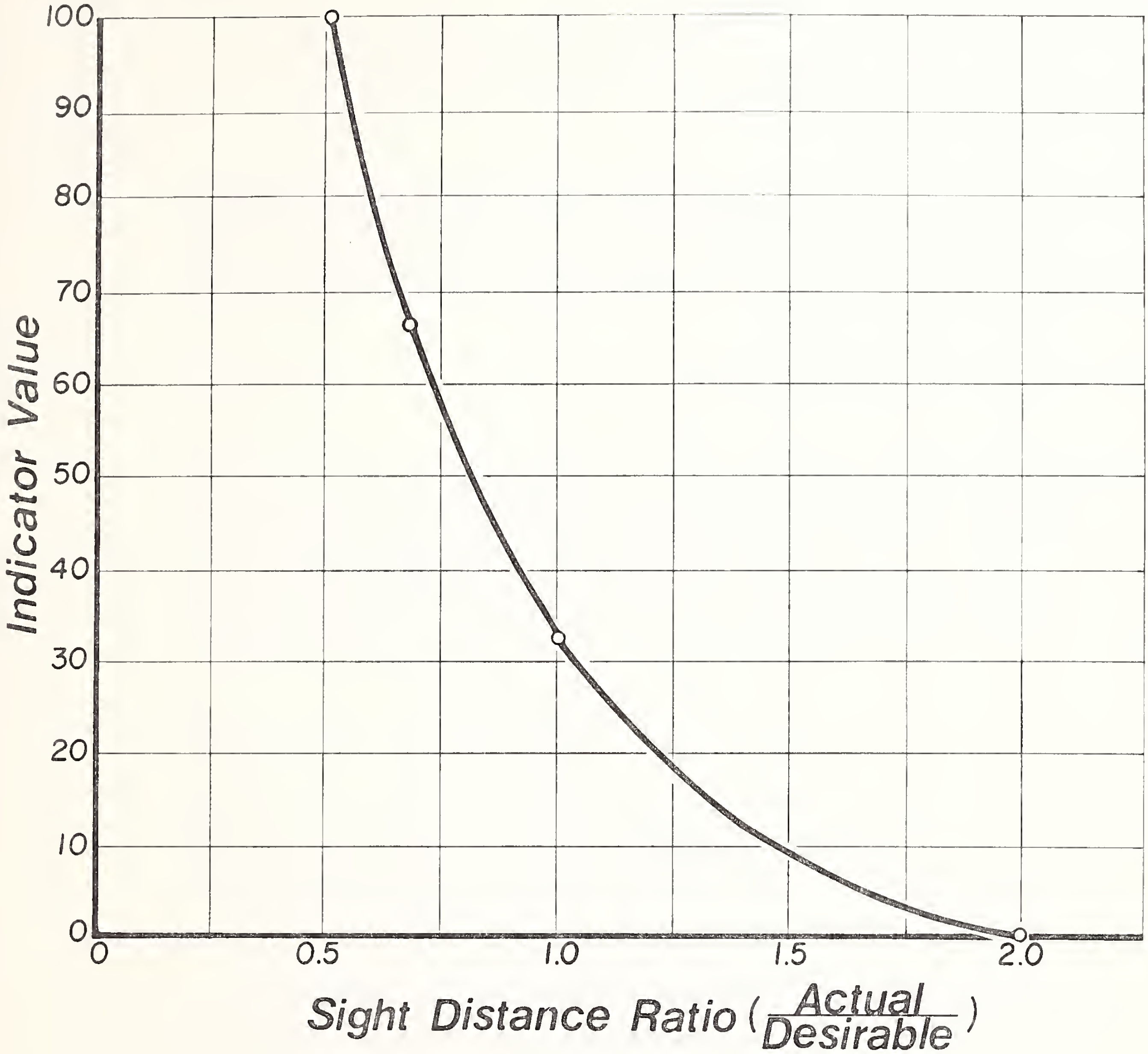

INDICATOR VALUE FOR ACCIDENT SEVERITY

FIGURE A5




INDICATOR VALUES FOR V/C RATIO

FIGURE A6




INDICATOR VALUES FOR
SIGHT DISTANCE

FIGURE A7

## DRIVER EXPECTANCY PROBLEMS RATING FORM

Ratings

0 Nothing unexpected or unusual at this location.
Actions required (if any) entirely consistent with driving strategy on approach.
Standard geometry, with pathway(s) for intended movement(s) clearly evident.
No intereferences by other traffic likely.

1

2

3 Situation somewhat unexpected.
Driver must be alert, but should be able to respond adequately at "last minute" to most combinations of adverse circumstances.
Some initial confusion on intended path(s) or movement(s).
Interference from other traffic may create some degree of confusion or uncertainty for average driver.

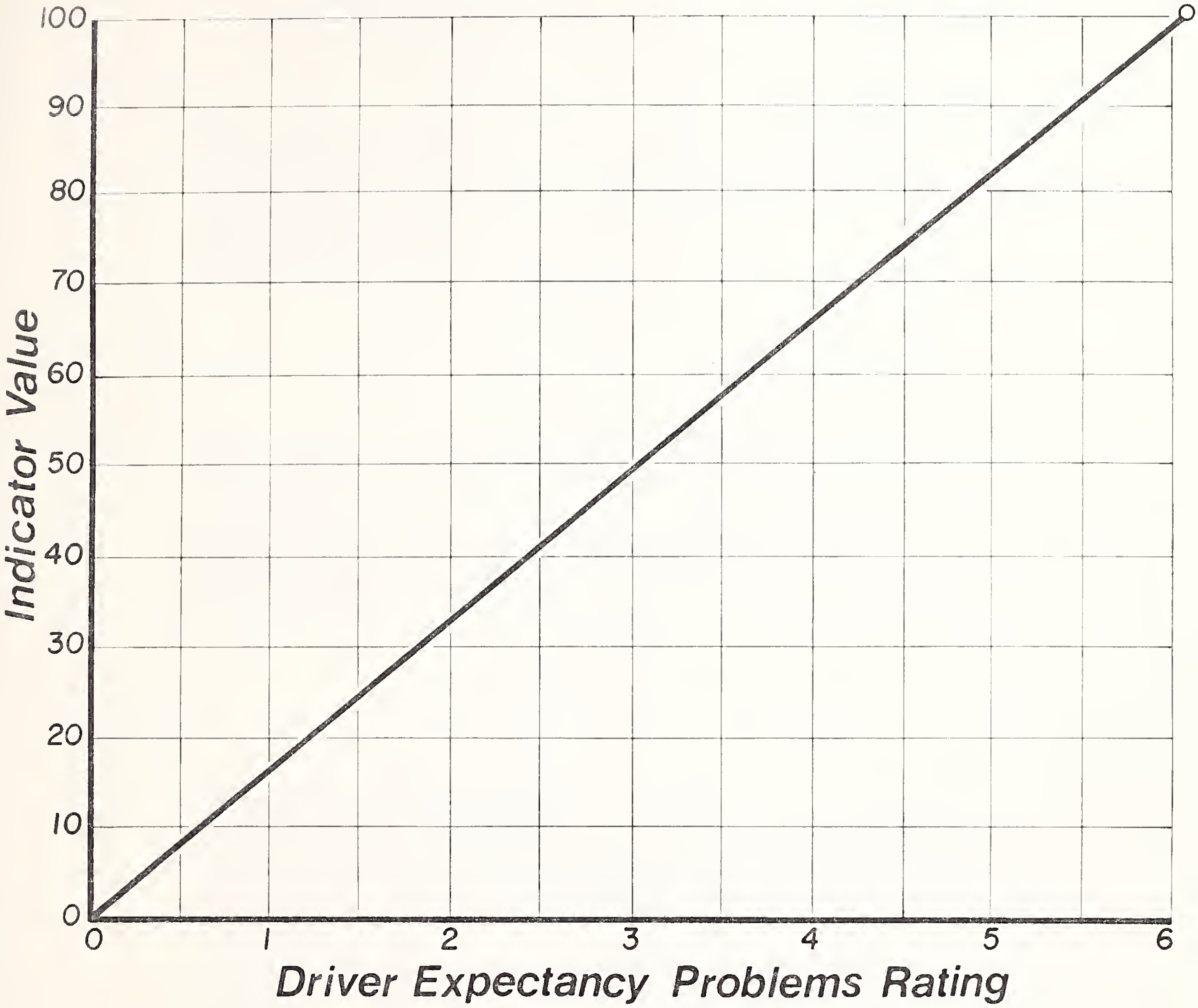
4

5

6 Very unusual situation; will surprise many unfamiliar drivers.
Driver required to make major changes in driving tactics from those employed over past few miles.
At least a "near accident" almost expected if driver is even moderately inattentive; evasive actions likely to be required.
Intended pathway(s) confusing under fairly normal traffic or lighting conditions.
Other traffic, or lack of it, aggravates situation and misleads driver or deprives him of important cues.

| Approach | Rating 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| A | | | | | | | |
| B | | | | | | | |
| C | | | | | | | |
| D | | | | | | | |

FIGURE A8




INDICATOR VALUES FOR
DRIVER EXPECTANCY

FIGURE A9

## INFORMATION SYSTEM DEFICIENCIES RATING FORM

Ratings

0 Information for required decisions complete and unambiguous.
Signs, markings, delineation in good repair, clean, highly visible.
"Positive guidance" leads driver to appropriate path; makes "error" difficult.
Approach speeds of most drivers are appropriate.
Light decision load; easy and obvious.

1

2

3 Some information lacking or somewhat misleading.
Signs should be moved or augmented for better visibility or to provide more decision time.
Visibility of signs, marking, and delineation barely adequate.
Medium decision load; average driver will be able to handle situation, but may be a little uncomfortable.

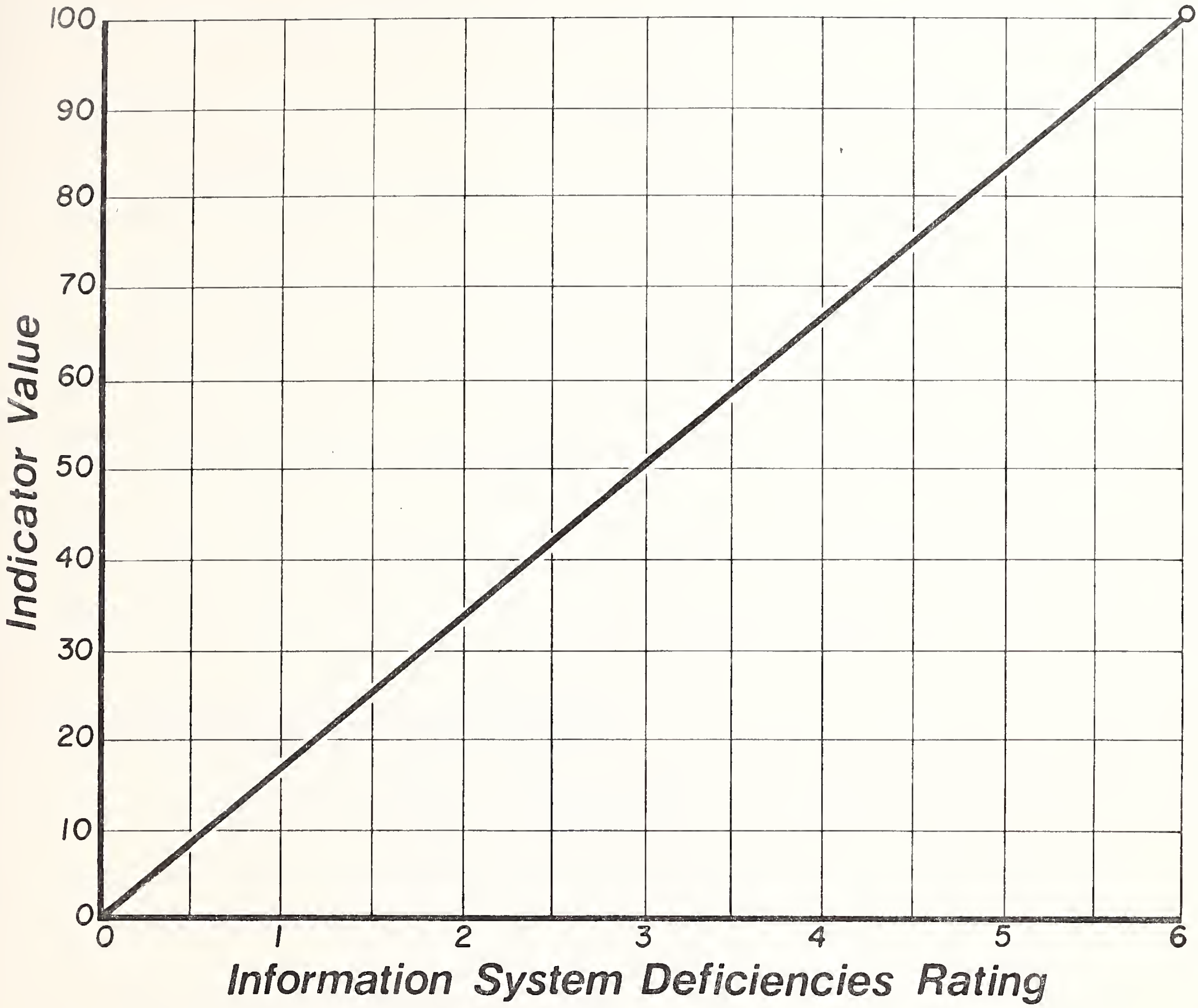
4

5

6 Important information missing.
Complete new "information system" needed — design and installation.
Present signs and markings in very poor condition; need replacement.
Speed limit and/or advisory speed needed; either missing or totally inappropriate at present.
"Positive guidance" on appropriate path lacking; a clutter of negative delineation only.
Heavy decision load; complete attention of average driver required; a "tense" situation at best.

| Approach | Rating | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| A | | | | | | | |
| B | | | | | | | |
| C | | | | | | | |
| D | | | | | | | |

FIGURE A10




# INDICATOR VALUES FOR INFORMATION SYSTEM DEFICIENCIES

FIGURE A11

## BENEFIT / COST RATIO WORKSHEET

Location: ______________________ Milepost: ______________________

Improvement Description: ______________________________________________

______________________________________________________________

Estimated Service Life ____________________ Years = T

Compounded Interest Rate ____________________ % = R

Current 19 ___ ADT ________________________

Time Frame for Accident Data: From _______ To _______ = _______ Years

### I. ANNUAL COST FOR THE IMPROVEMENT:

1. C = Capital Cost for Improvement $ ______________________
2. K = Capital Recovery Factor = $K = \dfrac{R(1 + R)^T}{(1 + R)^T - 1}$ = ______________
3. M = Change in Annual Maintenance or Operation Cost $ ________________
4. Annual Cost = (C K) + M = $ ________________________

### II. ANNUAL BENEFIT OF THE IMPROVEMENT:

1. $ADT_a$ = Average Daily Traffic After Improvement: ______________________
2. $ADT_b$ = Average Daily Traffic Before Improvement: ______________________
3. I/F = Ratio of Injuries to Fatalities for the Class of Highway Involved: __________
4. $Q = \dfrac{* + (I/F)**}{1 + I/F}$ = ____________ = ____________ = ____________

   * Current cost of a fatal accident from National Safety Council memo No. 113 = $ ________________

   ** Cost of an injury accident = $________________

5. Afi = Annual average number of fatal accidents and injury accidents combined at the location which will be affected by the improvement =

   $\dfrac{\text{No.}}{\text{Years}}$ = ______________________ = ______________________

FIGURE A12

6. Apd = Annual Average Number of Property Damage Accidents at the Location =

$\frac{\text{No.}}{\text{Years}}$ = ______________________ = ______________________

7. Pfi = Expected Percentage Reduction of Fatal and Injury Accidents by Improvement =

__________ %

8. Ppd = Expected Percentage Reduction of Property Damage Accidents by Improvement =

__________ %

a. $P_1$ = Largest percentage reduction in accident of any one of the improvements.

b. $P_2$ = Second largest percentage reduction in accidents of any of the improvements.

c. $P_3$ = Third largest percentage reduction in accidents of any of the improvements.

d. Pfi and Ppd for location where more than one improvement will be used in combination = $P_1 + \left(\frac{100 - P_1}{100}\right) P_2 + \left(\frac{100 - P_1}{100}\right)\left(\frac{100 - P_2}{100}\right) P_3 + \ldots$

9. Annual Benefit = $\frac{ADT_a}{ADT_b}\left[Q\,(Afi)\,pfi + {*}{*}{*}\,(Apd)\,Ppd\right]$ = ______________________

*** Cost of a property damage accident = $______________________

III. BENEFIT / COST RATIO = $\frac{\text{Annual Benefit}}{\text{Annual Cost}}$ = ______________ = ______________

FIGURE A12 (Continued)

## RELATIVE SEVERITY INDEX
## BY TYPE OF ACCIDENT *

| Multi-Vehicle, At Intersection | Urban | Rural |
|---|---|---|
| Entering at angle | $4,300 | $14,400 |
| From same direction – both going straight | 2,800 | 5,100 |
| From same direction – one turn, one straight | 2,500 | 5,100 |
| From same direction – one stopped | 3,800 | 5,200 |
| From same direction – all others | 2,000 | 6,300 |
| From opposite direction – both going straight | 4,000 | 20,000 |
| From opposite direction – one left turn, one straight | 4,400 | 15,400 |
| From opposite direction – all others | 2,700 | 3,800 |
| Not stated | 3,800 | 5,200 |
| **Multi-Vehicle, Non-Intersection** | | |
| Going opposite direction – both moving | $4,400 | $19,600 |
| Going same direction – both moving | 2,900 | 8,100 |
| One car parked | 1,600 | 2,400 |
| One car stopped in traffic | 4,200 | 6,800 |
| One car entering parked position | 1,900 | 2,300 |
| One car leaving parked position | 1,200 | 2,700 |
| One car entering alley or driveway | 3,400 | 6,000 |
| One car leaving alley or driveway | 2,000 | 4,400 |
| All others | 1,700 | 7,600 |
| Not stated | 3,400 | 6,000 |
| **Motor Vehicle with Pedestrian, At Intersection and Non-Intersection** | | |
| Vehicle going straight | $20,000 | $49,000 |
| Vehicle turning right | 13,600 | 11,200 |
| Vehicle turning left | 17,100 | 11,200 |
| Vehicle backing | 20,600 | 11,200 |
| All others | 14,500 | 11,200 |
| Not stated | 11,200 | 11,200 |

* FHWA-RD-77-87 "Identification of Hazardous Locations"

**TABLE A1**

| Single Vehicle, at Intersection | Urban | Rural |
|---|---|---|
| Collision with train | $26,700 | $39,100 |
| Collision with bicycle | 13,100 | 31,900 |
| Injury in vehicle, jacknifed | 5,200 | 2,000 |
| Collision with fixed object in road | 5,500 | 7,000 |
| Overturned in road | 9,200 | 7,500 |
| Left road | 5,200 | 12,300 |
| **Single Vehicle, Non-Intersection** | | |
| Collision with train | $26,700 | $39,100 |
| Collision with bicycle | 13,100 | 31,900 |
| Injury in vehicle, jacknifed | 5,200 | 2,000 |
| Collision with fixed object in road | 6,300 | 9,200 |
| Overturned in road | 10,000 | 9,400 |
| Left road at curve | 7,600 | 12,400 |
| Left road on straight road | 5,200 | 10,500 |
| **Other One Motor Vehicle, At Intersection and Non-Intersection** | | |
| Fell from moving vehicle | $15,000 | $57,200 |
| Collision with animal | 4,800 | 1,800 |
| Collision with other object | 4,700 | 4,400 |
| All others | 5,200 | 2,000 |
| Not stated | 3,200 | 3,400 |

TABLE A1 (Continued)